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ABSTRACT

This teacher's guide is designed to aid teachers in leading students through a module on aircraft welding on airframes. The module contains four units that cover the following topics: (1) gas welding and cutting; (2) brazing and soldering; (3) shielded metal arc welding; and (4) gas tungsten arc welding. Each unit follows a standardized format that consists of the following components: introduction and module objective, specific objectives, instructor's implementation guide, technical information supplements, transparency masters, workbook supplements, answers to workbook supplements, project guides, theory test, and answers to theory test. A course test with answer key completes the package. (KC)

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# AVIATION MAINTENANCE TECHNOLOGY

# AIRFRAME

# A204 AIRCRAFT WELDING

# INSTRUCTOR MATERIAL

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MODULE OF INSTRUCTION
FOR
AVIATION MAINTENANCE TECHNOLOGY

# AIRFRAME

## A204 AIRCRAFT WELDING

## PERFORM GAS WELDING AND CUTTING

## A204-A

AIRFRAME
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## INTRODUCTION

Aviation maintenance technicians are required to use gas welding and cutting tools and processes in the repairing and manufacturing of aircraft. In this module you will learn how to operate the oxyacetylene torch to cut and weld metal.

## MODULE OBJECTIVE

After completion of this module, you will be able to cut and weld mild steel. Your competency will be evaluated by completing workbook assignments, project guides, and by scoring a minimum of 85 percent on the module theory test.

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## SPECIFIC OBJECTIVES

After completion of this module, you will be able to:

| | | |
|---|---|---|
| 1. Match terms related to gas welding and cutting to their correct definitions. (1) | Technical Supplement #1 | |
| 2. Discriminate between safe and unsafe practices related to the handling and use of oxygen, acetylene, and oxyacetylene welding equipment. (1) | Technical Supplement #2<br>Workbook Supplement #1 | |
| 3. Match the gases hydrogen, oxygen, and acetylene to their proper characteristics. (1) | EA-ITP-AB | 191-192 |
| | AC 65-15A | 248 |
| | EA-ITP-AW | 3:II:15 |
| | Workbook Supplement #2 | |
| 4. Label parts of a torch body and cutting attachment. (2) | EA-ITP-AB | 199 |
| | AC 65-15A | 263 |
| | Workbook Supplement #3 | |
| 5. Identify oxyacetylene welding equipment. (1) | EA-ITP-AB | 191-195 |
| | AC 65-15A | 248-251 |
| | EA-ITP-AW | 3:II:15 |
| | Workbook Supplement #4 | |
| 6. List the causes of a backfire. (1) | Technical Supplement #3 | |
| 7. List the most common results of a backfire. (1) | Technical Supplement #3 | |
| 8. Describe how to recognize the occurrence of a flashback. (1) | Technical Supplement #3 | |
| 9. List in proper order the steps to follow if a flashback occurs. (2) | Technical Supplement #3 | |
| 10. Name factors that determine fusion weld quality. (1) | Technical Supplement #3 | |
| | AC 65-9A | 486-487 |
| 11. Name factors that determine tip size and factors that determine type and size of filler rod to be used in oxyacetylene welding. (1) | Technical Supplement #3 | |
| 12. State the primary purpose for using a filler rod. (1) | AC 65-15A | 251 |
| | Technical Supplement #3 | |

## SPECIFIC OBJECTIVES

| | | |
|---|---|---|
| 13. Match types of welding flames to their correct usages. (2) | EA-ITP-AB<br>AC 65-15A<br>EA-ITP-AW<br>Technical Supplement #3<br>Workbook Supplement #5 | 196<br>252-253<br>3:II:16 |
| 14. Label types of welding joints. (2) | AC 65-15A<br>EA-ITP-AW | 255-257<br>3:II:14-17 |
| 15. Set up equipment for oxyacetylene cutting. (2) | EA-ITP-AB<br>AC 65-15A<br>Project Guide #1 | 195-196<br>251-152 |
| 16. Turn on, light, and adjust cutting torch to neutral flame, and turn off oxyacetylene cutting equipment. (2) | Project Guide #2 | |
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| 18. Turn on, light, adjust, and turn off oxyacetylene welding equipment. (2) | Project Guide #4 | |
| 19. Lay beads on mild steel plate without filler rod. (2) | EA-ITP-AB<br>Project Guide #5 | 196 |
| 20. Lay beads on mild steel plate with filler rod. (2) | EA-ITP-AB<br>Project Guide #6 | 196-197 |
| 21. Weld a butt joint in flat position using mild steel. (2) | EA-ITP-AB<br>Project Guide #7 | 197 |
| 22. Weld a lap joint in flat position using mild steel. (2) | EA-ITP-AB<br>Project Guide #8 | 198 |
| 23. Weld a tee joint in flat position using mild steel. (2) | AC 65-15A<br>Project Guide #9 | 256 |
| 24. Inspect condition of completed welds. (3) | EA-ITP-AB<br>AC 43.13-1A&2A<br>AC 65-15A<br>Project Guide #10 | 198<br>30<br>258 |

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## INSTRUCTOR'S MODULE IMPLEMENTATION GUIDE

I. Order materials to supplement module

A. Videotapes: *Oxyacetylene Welding Series, EA-WBS*

(NOTE: This videotape series is available from International Aviation Publishers, P.O. Box 36, 1000 College View Drive, Riverton, Wyoming 82501-0036.)

B. *Welding Skills and Technology*, by Dave Smith, 1984

(NOTE: This book is published by McGraw-Hill, Gregg Division.)

C. Booklet: *Welding, Cutting, and Heating Guide*

(NOTE: This booklet is available from Victor Welding and Cutting Division, Denton, Texas.)

II. Implementation Suggestions

(NOTE: Have students read all available resource material related to specific objectives.)

| Estimated Teaching Time | | Theory | Lab |
|---|---|---|---|
| Objective 1 | Use Technical Information Supplement #1 to discuss the terms and definitions related to gas welding and cutting. Use a flip chart illustrating terms to aid in the discussion. Instructional Supplement #1 could be a very interesting supplement to this specific objective. | | |
| Objective 2 | Review Technical Information Supplement #2, and have the class complete Workbook Supplement #1. Use Transparency Masters #1-#12. Instructional Supplement #2 can be helpful in determining eye protection used for various welding and cutting jobs. | | |

| Estimated Teaching Time | | Theory | Lab |
|---|---|---|---|
| Objective 3 | Describe carefully the characteristics of acetylene, oxygen, and hydrogen gases. Be sure to emphasize any characteristics which can be detected by the five senses and all characteristics which make the gas hazardous to the work environment and the technicians working there. Invite a guest speaker to class to talk about oxyacetylene welding gases. Guest speakers from Victor, Airco, or Smith Welding Products Distributors are usually available. Have the class complete Workbook Supplement #2. | | |
| Objective 4 | Label the parts of the torch body and cutting attachment and explain their operation. Use Transparency Masters #13 and #14. | | |
| Objective 5 | Label the parts of the oxyacetylene welding rig and explain its operation. Use Transparency Masters #15-#19. After the torch and the rest of the equipment have been discussed in the classroom, take the class to the shop to identify all parts of the welding rig and torch. Review any pertinent safety precautions and rules. Have students complete Workbook Supplements #3 and #4. | | |
| Objectives 6-9 | Describe the causes and results of a backfire. Explain the differences between backfires and flashbacks. Describe how a flashback can be recognized and how the welder should react in the event of a flashback. Have the students review the applicable portion of Technical Information Supplement #3. | | |

## INSTRUCTOR'S MODULE IMPLEMENTATION GUIDE

| Estimated Teaching Time | | Theory | Lab |
|---|---|---|---|
| Objective 10 | Describe how a basic weld is made on mild steel. Be sure to point out the five factors that the welder controls which determine the quality of the weld. Show examples of welds that clearly show how variation in the five factors affect weld quality. Use Transparency Master #20. Review material in AC 65-9A, pages 486-487, and have the class discuss how the factors determining weld quality lead to a particular appearance of a finished weld. Have students review the applicable portion of Technical Information Supplement #3. | | |
| Objective 11 | Explain the factors which determine tip size of torch, type of filler rod, and size of filler rod to be used in oxyacetylene welding. Use Transparency Masters #21-#23 and applicable portion of Technical Information Supplement #3. | | |
| Objective 12 | Explain why a filler rod is used in oxyacetylene welding. Be sure to point out the different types of filler rods which are used with various base metals. Have examples of the different types of filler rods for the class to examine. Have the class review the applicable portion of Technical Information Supplement #3. | | |
| Objective 13 | Describe types of welding flames. Explain how to recognize each type of flame and how to adjust the torch to produce different flames. Explain the common usages for the different types of flames. Use Transparency Master #24 and applicable portion of Technical Information Supplement #3. Take the class to the shop and demonstrate adjusting the torch to produce various flames. Make sure all students are wearing proper eye protection. Have students complete Workbook Supplement #5. | | |

## INSTRUCTOR'S MODULE IMPLEMENTATION GUIDE

| Estimated Teaching Time | | Theory | Lab |
|---|---|---|---|
| Objective 14 | Show the class examples of the most common types of welding joints. Have the students complete EA-ITP-AW 3:II:14-17 on "Gas Welding and Cutting" as a review of material taught to this point. | | |
| Objectives 15-24 | Discuss Project Guides #1-#10 with the class. Review all pertinent safety rules and precautions, and demonstrate all procedures. The projects are designed to be completed separately or to be completed one after another. Have students complete the projects. Review the projects in class after all students have completed. Assign students Instructional Supplements #3-#6 as home reading on project days or whenever the supplements would be the most beneficial. | | |

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INSTRUCTIONAL SUPPLEMENT #1

# The Field of Materials-Joining

## History and Development of Materials-Joining

The use of materials dates back far into antiquity. Biblical references are made to the use of metal articles of iron, copper, silver, and gold as far back as 3000 to 4000 BC. Since materials are often not used as a single piece, the need for joining them obviously became apparent almost as soon as the material came into existence; this was limited not only to metals but also to articles made from wood, skins, fabric, synthetic materials, and composite articles. Joining methods for these materials did not include the variety of methods known to man currently; however, it is very possible that ingenuity was used in casting materials into the desired shape, forge welding materials together, or using adhesives. Tying with vines, or crude mechanical fasteners certainly were used, but it should be remembered that in some present day cultures crude methods of fastening are still employed.

Modern techniques for materials-joining, which utilize welding and its ancillary processes, originated somewhat before the turn of the 20th century. Though both electric and gas welding developed in this time period, it has been since 1920 that technological developments have caused welding related processes to be utilized more than any other in the joining of metals.

In the United States the use of welding related processes was rather limited until the early 1940s when the pressures caused by the national emergency of World War II forced the utilization of the fastest means possible in building ships, tanks, trucks, and other hardware used in the war.

Setbacks in the growth of welding during this time period were experienced as failures started to occur. The causes of these failures can be summarized as: a lack of knowledge with regards to metallurgical changes which result from welding; weld imperfections from improper techniques; some steels upon which welding was being performed were not suitable for welding; designers were not familiar with design criteria for welding; many designs included notches or stress risers which caused early failures when subjected to fatigue type applications.

Since 1950, welding in the United States has experienced phenomenal growth. Though problems are still encountered, the advantages of welding related processes outweigh the disadvantages and the following have been and are continuing to be developed: welding processes and consumables to join a continually growing list of materials; materials which are more easily joined, and still possess the desired properties; procedures with heat controls, process parameters, or other factors which have overcome problems.

Development of other materials-joining methods also is in progress. A greater variety of mechanical fasteners are now in existence. New adhesive fasteners are continually being developed for joining a bigger variety of materials with greater strength, minimizing the effort required in their use.

**Education in Materials-Joining**

Materials-joining as an engineering field in which one could receive training has not enjoyed wide acceptance.

The design of structures which use mechanical fasteners has been relegated to handbooks which outline the rules for dimensions and spacing of holes, along with the dimensions and type of mechanical fasteners. These standards have been proven over the years and designers feel safe in using them.

Adhesives have been developed by chemical engineers and though literature and advertisements of the products exist, educational curriculums that offer engineering training in the use of adhesives are extremely few. Therefore, the design engineer, and materials-joining engineer must become knowledgeable in the use of adhesives mainly through the manufacturers of such products.

Until the late 1940s most training or education in the field of welding and its ancillary processes was limited to skills. As of the 1970s many welding education programs existed in high schools, trade and vocational schools, as well as over 300 colleges still having the same emphasis. A very limited number of colleges and universities have recognized the field of welding as more than a skill and are offering four year or more programs in materials-joining, welding engineering and welding technology, leading to bachelor of science and higher degrees. The approach at these limited number of institutions is not standardized. The program may be offered by a department of welding or material-joining engineering, or may be an option within an engineering department, or may be a major within mechanical, industrial, or other engineering or technology program. There are a few universities not having welding or materials-joining engineering which have a welding area in their metallurgical departments. Also, individuals may elect after getting a bachelor degree in industrial, mechanical, electrical, or other engineering field to do postgraduate work in some phase of welding or material-joining.

*Variables* are the keys to what sets welding and related processes apart from mechanical fastening types of material-joining. Practically all of the welding and related processes currently in use involve heat input and/or upset in localized areas of the materials being joined. The heat affected zones exhibit changed mechanical properties, and these changes vary considerably depending upon the value or amount of heat input, and the kind of materials involved in the joining process. The preceding sentence has far reaching implications. Heat input varies considerably depending on the choice of joining process, that is, whether it is Shielded Metal Arc Welding, Gas Metal Arc Welding, or Electron Beam Welding, etc., and the variables within each process; that is amperage, voltage, travel speed, etc. Kind of materials include the base material, weld material, gases, fluxes, slags, shielding media, etc. The materials being joined vary considerably in how their properties are affected by the heat from joining processes. The ultimate in choosing and properly balancing these variables with respect to each other is responsible for making this phase of material-joining interdisciplinary. A summation of the involved disciplines follows:

Chemistry involves the composition of all materials, whether it is metals, plastics, ceramics, or composite materials. A knowledge of chemistry is helpful when formulating or working with these materials, and the materials used for beneficial chemical reactions such as cleaning, or for the prevention of unwanted chemical reactions such as the formation of iron oxide. Chemical reactions are also used in producing heat such as between a fuel gas and oxygen in gas welding and cutting, or between aluminum, and iron oxide in thermit welding.

Electricity is involved in producing heat which is used in the majority of welding processes to locally melt and allow coalescence of the materials involved to produce the weld. The electric equipment manufactured for this purpose must produce a properly balanced set of electrical variables to accomplish this, whether it be producing a smoothly tuned arc, electric resistance heating, or electromagnetic radiation. The equipment involved varies from relatively simple and inexpensive power sources to extremely sophisticated and expensive components. Electricity is also used in producing proper heat treatments, or for moving the welding head or work piece at the desired travel speeds with minimum vibration.

Material science involves the nature of the microstructure and localized changes of the microstructure resulting from welding, which cause changes of the mechanical and physical properties. Residual stresses and distortion result from the localized expansion and contraction which is restrained by base material adjacent to the heat affected zone. Microstructure of castings compared to wrought materials of the same chemical composition vary considerably, thus requiring study.

Mechanical engineering involves design of any products most of which include the joining of materials. Initially a decision must be made as to what portion of the structure will be casting, mechanically fastened, welded, brazed, or soldered. Structure analysis determines resulting stresses from applied loads, then weld size and/or joint configuration, and procedure must be determined to produce the structure. The objectives in design involve the ultimate in material selection and joint design to take advantage of the fastest material joining procedure practical for the application.

An individual could hardly be an expert in all of these disciplines, though all of them are involved in welding or weld related processes of material-joining. But a materials-joining engineer should be as proficient as possible in the areas of joining processes, and related areas of chemistry, material science, mechanical and electrical engineering.

Educating a materials-joining or welding engineer should include a well rounded balance of both the theoretical and practical. The theory is essential to serve as the basis for the practice. The preceding sentence is idealistic because there is much practice which has no actual theoretical basis, or is based upon theory which is not fact. Theory is based upon conclusions from observations, and theories are subject to change depending on the development of findings through advancement of scientific methods which occasionally nullify existing theories. An individual often finds large gaps between the theoretical and the practical. Those responsible for manufacturing products made from materials usually are more interested in getting the work done, rather than theories; however, the materials-joining engineer who knows the theories as to why a practice performs satisfactorily or not is most effective when abreast of the latest findings. He will more likely be able to solve the problems, or take a short cut on an existing practice thus cutting manufacturing costs, again having sound basis for his decisions. His proficiency in affecting developments will depend upon his command of both theory and practice.

Based on the preceding paragraph the educational program of the materials-joining engineer should contain laboratory work where the student does exercises and experiments exposing him to processes and procedures, and where he can develop practical ability. This is not to say that he must become an expert welder, riveter, mechanic, foundryman, and electrician. But he should gain enough proficiency so that he is able to make a reasonably good weld with any of several processes, and know the advantages and limitations of the various processes. With this kind of ability he can write a more realistic procedure, is more effective in training operators, is more respected by shop personnel, and is more confident in doing a job for his company.

In addition to the laboratory experience, it is of great value for the potential engineer to work part time, during the summers, and/or a cooperative education program on a practical job. Though decidedly more limited in scope, the job will expose him to the difference between lab exercises, and putting a product together. Also the sociological experience gained from such an exposure serves to mature him, and give him appreciation of the problems faced by shop and management.

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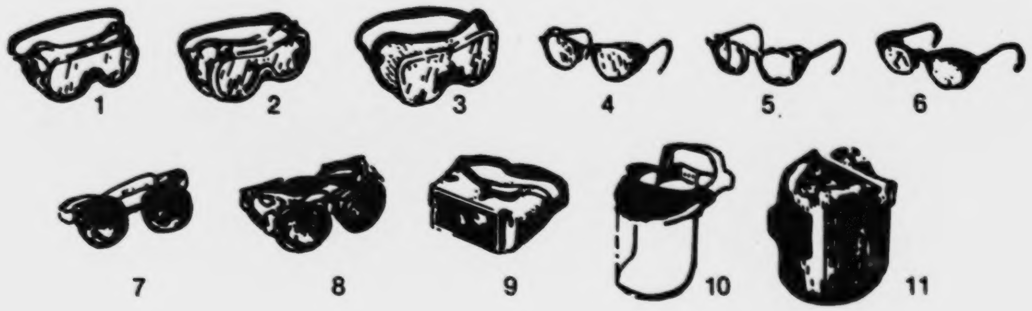
## INSTRUCTIONAL SUPPLEMENT #2 — Eye and Face Protector Selection Chart

**USAS Z87.1-1968**
USA STANDARD PRACTICE FOR OCCUPATIONAL

### Selection Chart
**Recommended Eye and Face Protectors for Use in Industry, Schools, and Colleges**



1. **Goggles**, Flexible Fitting, Regular Ventilation

2. **Goggles**, Flexible Fitting, Hooded Ventilation

3. **Goggles**, Cushioned Fitting, Rigid Body

*4. **Spectacles**, Metal Frame, with Sideshields

*5. **Spectacles**, Plastic Frame, with Sideshields

*6. **Spectacles**, Metal-Plastic Frame, with Sideshields

7. **Welding Goggles**, Eyecup Type, Tinted Lenses (Illustrated)

7A. **Chipping Goggles**, Eyecup Type, Clear Safety Lenses (Not Illustrated)

8. **Welding Goggles**, Coverspec Type Tinted Lenses (Illustrated)

8A. **Chipping Goggles**, Coverspec Type, Clear Safety Lenses (Not Illustrated)

9. **Welding Goggles**, Coverspec Type, Tinted Plate Lens

10. **Face Shield** (Available with Plastic or Mesh Window)

11. **Welding Helmets**

*Non-sideshield spectacles are available for limited hazard use requiring only frontal protection.

**Applications**

| Operation | Hazards | Recommended Protectors<br>(See Selection Chart on previous page) |
|---|---|---|
| Acetylene-burning<br>Acetylene-cutting<br>Acetylene-welding | Sparks, harmful rays, molten metal, flying particles | 7, 8, 9 |
| Chemical handling | Splash, acid burns, fumes | 2, 10 (For severe exposure add 10 over 2) |
| Chipping | Flying particles | 1, 3, 4, 5, 6, 7A, 8A |
| Electric (arc) welding | Sparks, intense rays, molten metal | 9, 11 (11 in combination with 4, 5, 6, in tinted lenses, advisable) |
| Furnace operations | Glare, heat, molten metal | 7, 8, 9 (For severe exposure add 10) |
| Grinding—light | Flying particles | 1, 3, 4, 5, 6, 10 |
| Grinding—heavy | Flying particles | 1, 3, 7A, 8A (For severe exposure add 10) |
| Laboratory | Chemical splash, glass breakage | 2 (10 when in combination with 4, 5, 6) |
| Machining | Flying particles | 1, 3, 4, 5, 6, 10 |
| Molten metals | Heat, glare, sparks, splash | 7, 8 (10 in combination with 4, 5, 6, in tinted lenses) |
| Spot welding | Flying particles, sparks | 1, 3, 4, 5, 6, 10 |

## INSTRUCTIONAL SUPPLEMENT #2

### Selection of Eye and Face Protective Devices*

| Hazards Involved | Part to Be Protected | Types of Permissible Protective Devices |
|---|---|---|
| Relatively large flying objects | Eyes, face | Goggles, spectacles, face shields |
| Dust and small flying particles | Eyes, face | Goggles, spectacles, face shields |
| Dust and wind | Eyes | Goggles, spectacles |
| Molten metal | Eyes, face | Goggles, spectacles, face shields |
| Gases, fumes, and smoke | Eyes, face | Goggles |
| Liquids | Eyes, face | Goggles, face shields |
| Reflected light or glare | Eyes | Goggles, spectacles |
| Injurious radiant energy (moderate) | Eyes | Goggles, helmets, hand shields face shields |
| Injurious radiant energy (intense) | Eyes, face | Helmets, hand shields |

*Source: California Industrial Arts Safety Instruction.

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INSTRUCTIONAL SUPPLEMENT #3

# "Are You Having Problems With Your Welding?"

by Reed Nielson

I visited one of my A&P-IA friends at the local F.B.O., where he was making a repair on a steel tubular airframe in accordance with AC43.13-1A. Because of my interest in welding, I looked closely at the preparation for the welding, and at the subsequent welding. I was somewhat surprised at the job which resulted. It was not one that I would have been excited to accept. My friend confided in me that he wasn't exactly proud of the job himself. Knowing that I held an A&P license, and I had held an IA for several years, and that I was a qualified aircraft welding instructor, he asked for some tips that would help him in the future.

The first suggestion was that he needed to practice his welding. He, like many others, learned by trial and error, or maybe even had an introductory class; and now because of his busy schedule, welds only when necessary. When I questioned him, he said it had been about eight months since his last welding repair.

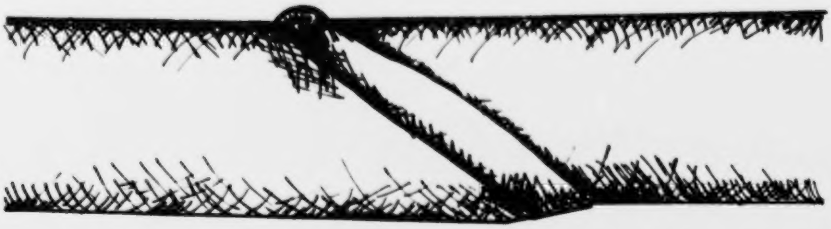
At best, welding is a complex skill that is probably less understood than other mechanical skills. It takes a great deal of practice to become proficient, and requires regular practice or use to keep the skill level up to par. It's kind of like using radio navigation aids for instrument flight. If you don't use the navigation aids for a couple of years, you become rusty, and probably wouldn't feel confident to make an instrument flight approach in heavy traffic at a complex airport. If it was necessary you would probably make it, but you may not be too proud of the job. A little review of the procedures, and some practice, would pay great dividends.

If it has been awhile since you welded, you should practice and become current on the same type joint that you are going to use in the repair, before actually making the repair. This means that you should run some beads on a practice plate and then actually make up a slip-sleeve repair practice joint, if that is the type of repair you are going to do on the airframe. The material, material thickness, etc., should all be the same. The same care should be exercised in preparing and doing the practice joint as for the real thing.

The second suggestion was that he spend a little more time preparing the tube for welding. The ease of welding is directly proportional to the joint fit-up and to the accuracy to which the cut and fit is made. If the gap is too large, too small, or varies, it is difficult to get a consistent bead profile and even penetration. Cutting, deburring, cleaning, and fitting must all be done accurately and completely before starting to weld.

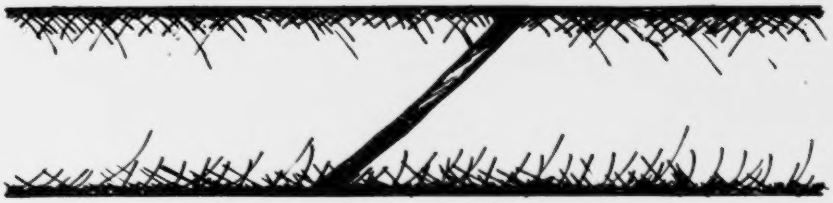
The design of the repair is an important aspect of this preparation. Accessibility to the weld and the type of repair should all be given careful consideration. As Figure A shows, my friend didn't match the scarfed angles on the inside sleeve repair very well. As you can imagine, the weld would be considerably more difficult to make than the weld on a properly prepared joint as shown in Figure B.

FIGURE A: Poor fit-up



**This joint is fitted so poorly the tubing doesn't line up. A good weld starts with proper welding gap between the tubes.**

FIGURE B: Correct fit-up



**A good joint has equal angles on both tubes. Proper gap assures good penetration.**

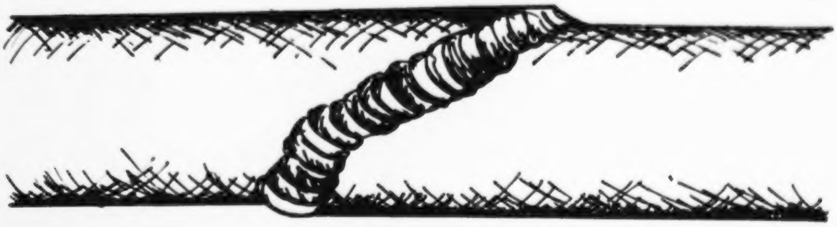
Figures C and D show the respective welds that were made on the joints in *A* and *B*. I don't think it takes much experience to see the difference in the welds. The weld in *D* is smooth, even and tied into the base metal while the weld in *C* is rough, uneven, and appears to have been difficult to do.

At this point it is important to stress that this joint preparation isn't a cure-all to your welding problems, but it definitely will help in your effort to do an airworthy job.

The third suggestion was to make sure that he had the correct tip and flame adjustment. Most manufacturers of welding torches recommend the tip size for a given metal thickness. If the tip is too small, the flame will be too harsh or forceful when turned up to the point that welding can take place. In this condition you may even have the flame blow away from the end of the tip as the torch tip heats up. The biggest problem with having too small a tip is the possibility of lack of penetration. Because of the small amount of heat, the puddle forms very slowly. The tendency is to get impatient and put the filler wire into the puddle before the puddle is fully established, thus cooling the puddle and reducing penetration. The bead will most always look rough and cold at the edges.

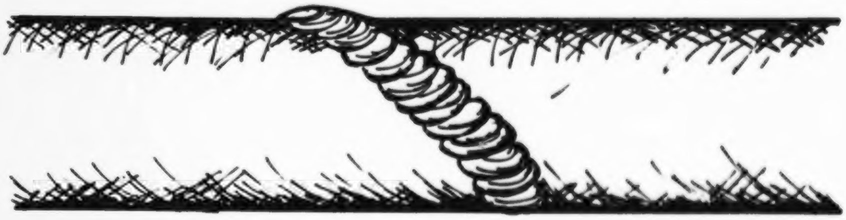
Using a tip too large causes the puddle to establish too quickly. On thin wall 4130 tubing, the result may be burn through or excess penetration. The bead will also be flat and show signs of excess penetration, much like the bead in Figure C. Again, during practice, select the tip that does the job best. To emphasize this point further, if you are to remove a 1/2" nut you don't use a 7/16" or 9/16" wrench. If you don't have a 1/2" wrench, you buy one to do the job right. Get the correct tip if you don't have it.

FIGURE C: Poor welds done on poor fit-up



The primary inspection for welds is "If it doesn't look good, it isn't." When welded with poor fit-up, tubing can be misaligned.

FIGURE D: Acceptable weld made on good fit-up



The tubing is straight, and weld bead uniform. A good weld looks good.

I suppose that along with the right tip goes adjusting the flame properly. Again, the torch manufacturer's recommends working pressures for each tip size used. For small tip sizes used on aircraft tubing, both the oxygen and acetylene are normally adjusted to three to five psi. A rule of thumb, which can be used if you don't have the manufacturer's recommended pressures for your torch, is to adjust the acetylene and oxygen regulators to give you just enough flow for the desired flame. Too much pressure will give you a harsh flame; while too little pressure will restrict the amount of heat put out by the torch. The flame should be adjusted to neutral. If, for any particular reason your torch cannot be adjusted to exactly neutral, it can be adjusted very slightly carburizing (excess acetylene) for 4130. When I say very slightly, I mean that the acetylene feather can just start to appear. It is important that an oxidizing (excess oxygen) flame *not* be used. Excess oxygen will combine with the molten metal creating iron oxide which leaves a brittle, weak weld.

A fourth suggestion was for him to take the time to really clean his welding goggles. He had not used his welding equipment for eight months. The goggles looked like they had a little of the accumulated dust blown off, but were still plenty dirty. Dirty welding lenses should be removed from the goggle frame and washed carefully. This will allow you to see more detail in the weld puddle. This is just one of the little things we shouldn't have to be told about, but we get in a hurry and usually neglect it.

Also, if you need glasses for reading, you should have them on for welding. If you don't wear your glasses you simply will not see the detail of the puddle that will give you a good bead appearance. Let's face it, it's pretty difficult for a blind man to weld by braille. If your goggles are dirty or you don't have your glasses on, you're trying to weld partially by braille.

Each of these four suggestions are pretty elementary, however, they are probably most often violated by the occasional welder. Practice, preparation, correct flame, and good vision, will all go a long way in helping you achieve a well proportioned, good appearing, strong weld.

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AIRFRAME
A204 AIRCRAFT WELDING
PERFORM GAS WELDING AND CUTTING
A204-A

INSTRUCTIONAL SUPPLEMENT #4

# Aircraft Welding Tips

by George Townson

Welding is basically the process of melting two or more pieces of metal and joining them together into one piece while molten.

The main objective while doing this is to join them with enough "penetration" to form a strong connection without destroying the metal by overheating. While this always seems simple enough there are a lot of "tricks of the trade" most of us learn after so many hours at the welding table. To save you a few moments of anguish, here are a few things you may want to remember the next time you pick up a torch.

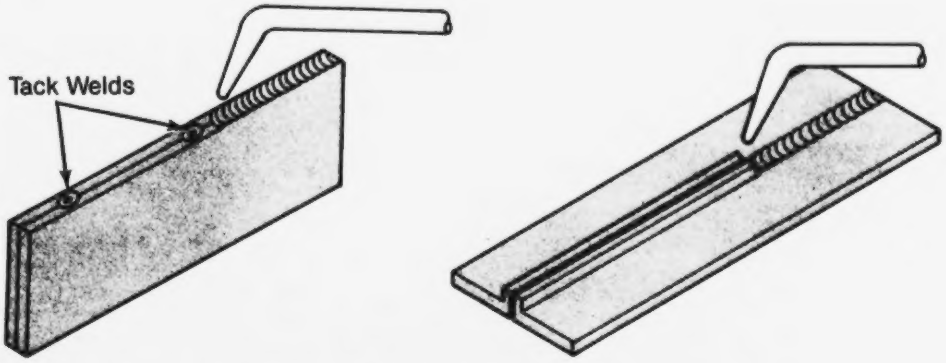
In most cases metals being joined together must be the same composition. 4130 steel may be joined to 1020 steel or very tough wear-resisting alloys like Stelite may be added to another steel for special purposes. Essentially, a weld may be made by melting one piece into the other or a filler rod may be used by adding it to the molten puddle at the joint.

## Edge Welding

"Edge welding" is the most common and simplest method of joining metals together without a filler rod. Sometimes the two are welded by merely melting the two edges and letting them flow together. If the metal can first be flanged up, they can be quickly melted and run together into a flat weld (Figure E).

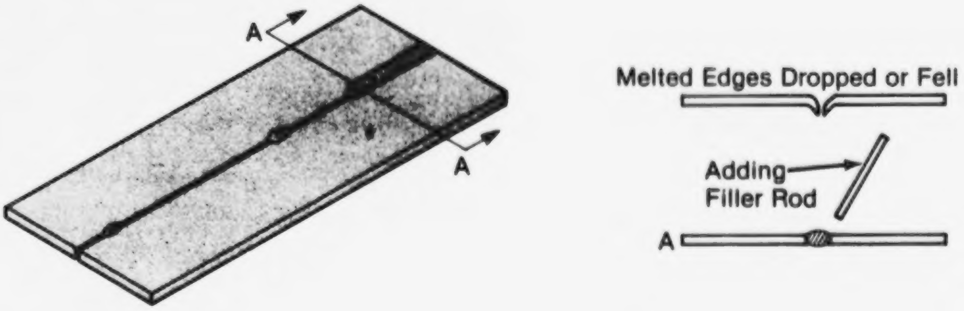
Often a filler rod may have to be added to get the weld or puddle started. Then the weld can progress without filler rod. Gravity

FIGURE E



Edge Welding Without Filler Rod

FIGURE F


A
A
Melted Edges Dropped or Fell
Adding Filler Rod
A

assists edge welding without filler rod because the metal wants to "fall down" as it melts and in doing so, joins together.

In welding pieces edge-to-edge, gravity can be a handicap. The molten metal wants to fall down and does not want to join together. Adding metal from a filler rod assists in making the metal join (Figure F).

When welding an "L" or inverted "T" the metal wants to fall down from the vertical member onto the horizontal member and undercut the vertical (Figure G). The heat should be concentrated on the horizontal, moving to the vertical when a puddle has formed on the horizontal. Add filler to prevent undercutting and to make a fillet between the horizontal and the vertical (Figure H).

When a thick piece must be joined to a thin piece, concentrate the heat on the thicker piece until a puddle is formed (See Figure I). If possible, hold the "T" between fire bricks as shown in Figure J so gravity can assist the puddle in forming.

Whenever you can, make yourself as comfortable as possible, position the parts to be welded in as handy a position as you can.

FIGURE G

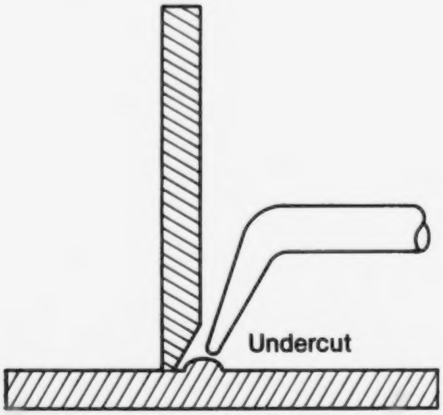


FIGURE H

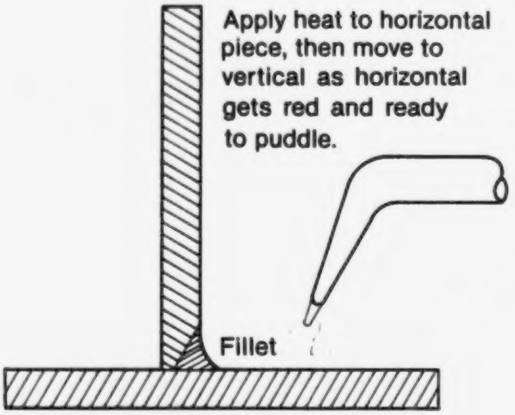
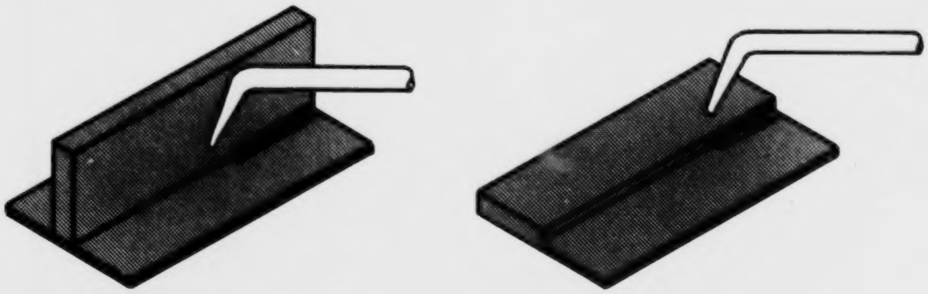

Apply heat to horizontal piece, then move to vertical as horizontal gets red and ready to puddle.
Fillet

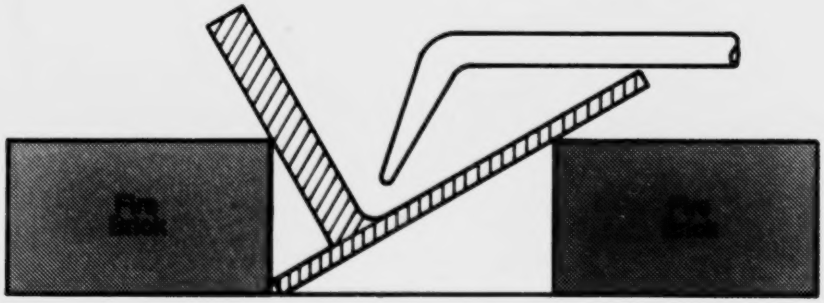
FIGURE I



Apply heat to heavier piece until it gets red and ready to puddle, then move down.

Apply heat to heavier piece first, then move to lighter piece.

FIGURE J



Try to set "T" or "L" up so gravity will assist puddle.

**Torch Angle**

As you progress with your weld, with your torch at an angle, pointing in the direction you are welding, the end of the pieces being welded will melt ahead of you and want to fall away. Hold the torch straight up or even pointing back toward where you came from (See Figure K), as you come to the end of the weld. This way you will not preheat the metal ahead of you.

It may even be necessary to lift the torch away, let the metal solidify, then melt the puddle again; lifting the torch, melting again and adding a small amount of rod each time. Each puddle should overlap the previous one.

FIGURE K

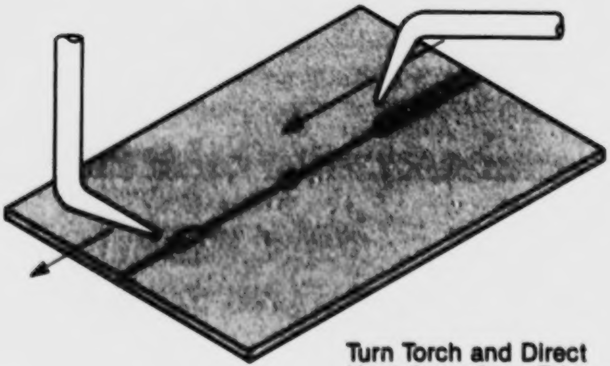
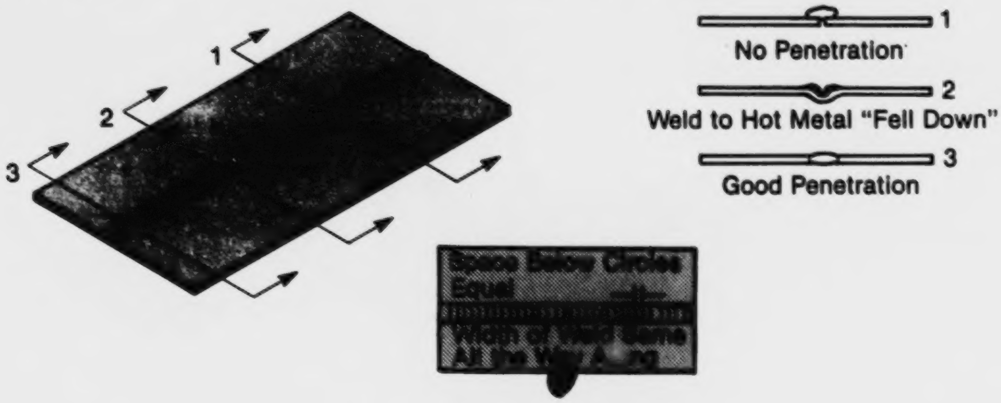

Turn Torch and Direct
Heat Away from Edge

FIGURE L


1
2
3
1
No Penetration
2
Weld to Hot Metal "Fell Down"
3
Good Penetration
Space Below Circles
Equal
Width of Weld Same
All the Way Along

When the puddle solidifies and is high above the surface, it generally indicates little penetration or too much rod has been added (Figure L1).

A "sunken weld" with drops of metal on the bottom side of the weld shows that the weld has been too hot and the metal sank through (Figure L2).

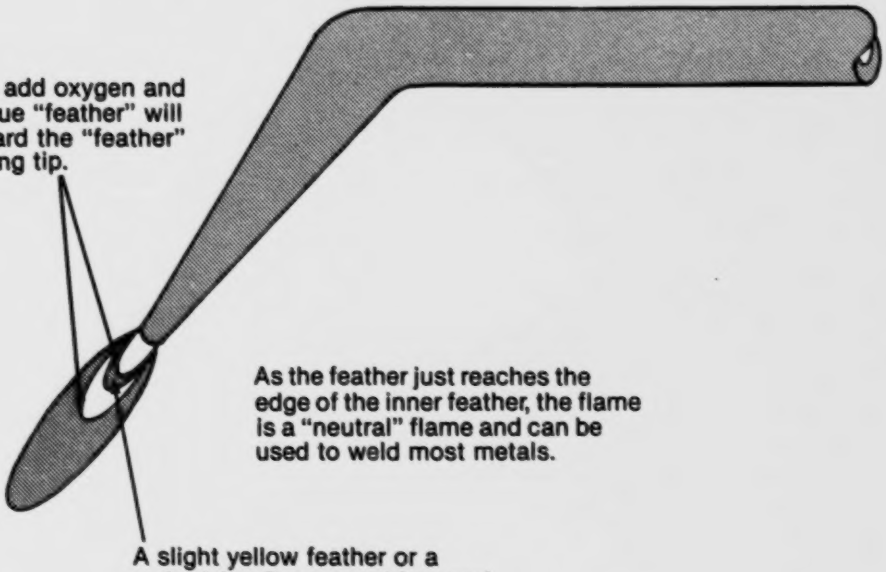
A good weld will look nearly the same on the top and bottom (Figure L3). The edges of the solidified puddle should be well defined and evenly spaced.

**The All Important Flame**

When the circles of the puddle edges are not well defined, your flame is usually "carburizing." This is when the flame will show another feather outside the feather closest to the tip. A lot of "sparking" during the welding means that you have an oxidizing flame and the metal is usually burning up. As a result, your puddle will not have the clear circles and can show evidence of bubbles in the metal. If there is any doubt about the adjustment of your flame, stop, close the oxygen valve until this feather turns blue

FIGURE M

After lighting the torch the acetylene will burn with a yellow-orange flame with a black tip. The black may come off the flame as soot as oxygen is added. The flame will change to blue.



Continue to add oxygen and the inner blue "feather" will recede toward the "feather" at the welding tip.

As the feather just reaches the edge of the inner feather, the flame is a "neutral" flame and can be used to weld most metals.

A slight yellow feather or a carburizing flame must be used for welding stainless steel.

and just barely disappears into the inner blue flame. This is called a "neutral" flame which you can use for *most* welding applications.

Welding stainless steel, however, is a different matter. The best weld here is usually accomplished with a small feather showing beyond the inner blue flame (Figure M). This is a *slightly* carburizing or "reducing" flame.

**Welding Aluminum**

Mechanics are usually scared away from aluminum welding. It is not really any harder than welding steel, if you keep a few things in mind. It takes *more* heat to weld aluminum because the aluminum conducts the heat away from the weld into the rest of the part.

All aluminum alloys are not readily torch weldable; 2024, 2017 or 7075 are some of the types that are not. If they do weld, they lose their original strength. However, 1100 and 5052 alloys are readily welded.

The *most important* thing to remember about aluminum welding is *cleaning the metal*. The area to be welded must be cleaned *just prior* to being welded. The filler rod must be cleaned. Clean the edges and top and bottom of the aluminum parts with an abrasive pad and a cleaner like "Aluma-

Brite" or "Turco WO-1". Weld *immediately* after cleaning the filler rod and weld area. This is because aluminum oxidizes rapidly on the surface. The oxidation melts at a higher temperature than the base metal and makes it difficult to see the aluminum melt as well as interfering with the metal being united.

The filler rod should also be selected for compatibility with the type of aluminum to be welded. The best filler is made by cutting strips $^{1}/_{16}$" to $^{1}/_{8}$" wide from the same material as the base metal. If you cannot do this, then you must rely on a good commercial rod.

Here's another thing. The heat conductance in aluminum is quite fast! For example, if you took a piece of aluminum a foot square and began to weld it to another piece, the entire sheet would be too hot to touch before the welding was finished. If the material was steel, the edges furthest from the weld could be touched after welding was finished.

Also, aluminum does not signal its readiness for welding by getting red, yellow and white before melting. It gets shiny. This is more apparent if the aluminum has been cleaned of all oxidation. *It must be cleaned thoroughly just before welding.*

### Using Flux

A flux must be used to further clean the filler rod and to keep the atmosphere away from the weld as the job progresses.

The flux is usually a dry powder. It must be fresh and the container kept sealed when not in use. The flux is mixed with water to make a creamy paste. the joint and filler rod are coated by applying the flux with a brush.

### Using Heliarc Equipment

All the welding discussion up to now has been about gas welding or torch welding. Both steel welding and aluminum welding are simpler if you have heliarc or TIG welding equipment available (TIG means *T*ungsten *I*nert *G*as).

With heliarc or TIG you have finite control of the welding heat without having to change any tips as you would in gas welding. A tungsten electrode is used to create the arc and this makes the heat that melts the metal. There are ***different*** sizes of electrodes too (ie., .040" diameter, $^{1}/_{16}$th, $^{3}/_{32}$nds, etc.). They come in *different* percentages of tungsten. Some percentages do a better job on certain metals than others. *Each diameter will weld a certain range of thickness of metal best.* A foot-controlled rheostat provides quite a range of amperage. You can start with higher amperage to begin your weld and drop back as the metal gets hot, or you can instantly increase or decrease the heat to go over a place where the metal is thicker or thinner.

The biggest advantage, perhaps, is the ease with which you can weld aluminum because the inert gas (usually argone) which envelopes the weld preventing oxidation as you melt the aluminum. A flux is not needed. Again, the precise heat control lets you apply more heat to get started and reduce the heat as you progress. The area to be welded should *still* be thoroughly cleaned just prior to welding.

The techniques described for steel welding such as for edge welding or thick-to-thin welding are the same.

### Get Comfortable

Make yourself as comfortable as you can. Sit down. Place the work in a convenient position. Your welding on-the-job will not always permit you to have comfort, but if you practice in comfort and do as many welding jobs in comfort as you can, the positions you sometimes have to assume—upside-down or squeezing yourself through a small hole to weld will seem to be easier.

### Torch Pressures

When I watch some of the young mechanics weld who are new to the welding table, I usually see them suffering with torch pressures.

Most of them try to use "5 and 10"—5 pounds acetylene and 10 pounds oxygen.

Most maintenance on light aircraft is welding on metal no thicker than 1/8". The tables below show the recommended pressures for welding aluminum and steel with various size welding tips. The tip manufacturer assigns the tip size number to the tip which may or may not suggest the actual diameter of the hole in drill number size or dimension.

Notice that the pressures are not the "5 and 10" that many young mechanics try to use. A pressure higher than necessary for the thickness of metal could blow a hole in the metal at your puddle.

### Regulator Valves

Before opening the tank valves make sure that the regulator valves are closed (all the way counterclockwise).

**Welding Tip Table**

| Tip Number | Orifice Drill Size | Pressure* Each Gas (PSIG) |
|---|---|---|
| 2000 | 78 | 3 |
| 200 | 76 | 3 |
| 20 | 74 | 3 |
| 201 | 71 | 3 |
| 202 | 69 | 3 |
| 203 | 67 | 5 |
| 204 | 63 | 5 |
| 205 | 57 | 5 |
| 206 | 56 | 5 |
| 207 | 54 | 8 |
| 208 | 52 | 8 |
| 209 | 49 | 8 |
| 210 | 44 | 11 |

*Regulator gauge settings may have to be set higher due to variables such as hose length, hose connection check valves, flashback arrestors and inconsistencies of commercial gauges.

Used with permission of Smith Welding Equipment Division, Tescom Corporation, Watertown, South Dakota.

**Pressure & Metal Thickness Table****

| Metal Thickness | Diameter of Orifice In Inches | Oxygen Pressure | Acetylene Pressure |
|---|---|---|---|
| .020"-.025" | .025" | 1 | 1 |
| .031"-.040" | .035" | 1 | 1 |
| .050"-.072" | .045" | 2 | 2 |
| .080"-.101" | .055" | 3 | 3 |
| 1/8"-3/16" | .065" | 4 | 4 |
| 1/4" | .075" | 5 | 5 |
| 5/16" | .085" | 5 | 5 |
| 3/8" | .095" | 6 | 6 |
| 5/8" | .105" | 7 | 7 |

**For welding aluminum

Used with permission of Aluminum Company of America, Pittsburgh, Pennsylvania.

When setting the regulator pressure have the respective torch valve open. Slowly turn the regulator valve in (clockwise) until the proper pressure is reached. Set each regulator (oxygen or acetylene) separately.

When tank pressure is low don't try to get more pressure at the torch by screwing in the regulator farther. Install a full tank. When shutting down, close both tank valves. Open the oxygen and acetylene valves at the torch *one at a time* and bleed down the hoses and regulators. Wind the regulator valves counterclockwise. Close the torch valves. There should be no pressure showing on any of the gauges.

**Welding Safety**

Safety is a very important consideration with any kind of welding. You have a potential making a fire or an explosion with your welding weapon.

Don't weld or flame cut any container that *ever* had a flammable material or an unknown substance in it. The only safe way to prepare a fuel or oil tank for welding is to steam it out for 12 hours with *live* steam. Because a container has been *empty* for a long time doesn't mean that fumes are not trapped in the seams that will be released when you heat the metal to weld it. Live steam will expand the metal and seams to release the fumes and make it safe to weld.

Filling the container with water to weld it is not absolutely safe practice and the water will absorb most of the heat. Putting dry ice in the container to give off $CO_2$ to prevent combustion never appealed to me, or piping exhaust fumes into the tank for the same reason never made me feel at ease. ***If there is any doubt, don't weld it!***

Be certain that there are no combustibles close by that could be ignited by a drop of molten falling on the floor or a spark from the torch. Keep a bucket of water with wet rags in it on hand. Have a fire extinguisher and a water hose that is ready to spray in an instant. See that nothing that you are wearing and there is nothing in your pocket that is easily combustible (such as a disposable lighter or matches). Don't open your oxygen or acetylene valves more than a half a turn, so in the event something happens a quick twist of the wrist will shut them off. This will often stave off an unwanted fire.

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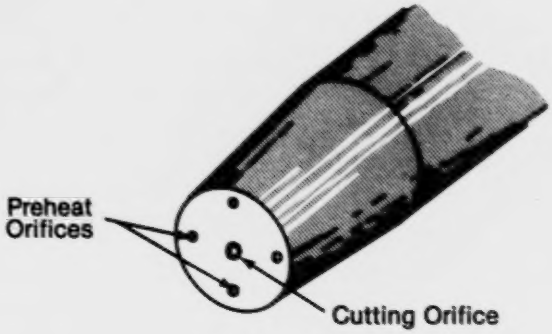
## INSTRUCTIONAL SUPPLEMENT #5 — Oxyacetylene Cutting Tips

A. Why cutting tips are designed as they are (Figure N)

EXAMPLE:

FIGURE N



1. Cutting tips can be quickly changed so cutting can quickly be adapted to different thicknesses of metal
2. Cutting tips are designed with two types of orifices, two or more preheat orifices, and one oxygen orifice
3. Preheat orifices provide a mixture of oxygen and acetylene for preheating the metal
4. The single oxygen orifice directs a pressurized stream of pure oxygen onto the heated metal to accelerate the oxidation process that burns the metal away and completes the cut
5. Oxyacetylene welding tips are put on finger tight, but some cutting tips have to be tightened with a wrench

B. Rules for cutting tip selection

1. Determine thickness of material to be cut, and use the size tip recommended by the manufacturer
2. Tip size has a direct relation to gas regulator pressures, and pressures recommended by the manufacturer should always be followed

3. Tip size affects rate of cutting speed and should be based on the needs of the cutting application

4. Tip orifice should be compatible with nature of work and fuel gas used

C. Cleaning cutting tips

1. Because cutting tips inevitably pick up slag, they need to be cleaned often

2. The cleaning probe should always be smaller in diameter than the orifice being cleaned, and a cleaning probe larger than the orifice should never be forced into the orifice

3. Care should be taken not to break off the cleaning probe inside the orifice

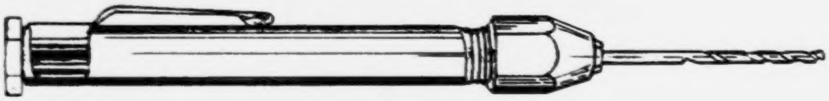
4. Be careful with the seating edges of cutting tips because some of them can be easily damaged

D. Tip cleaning tools and their uses

1. Tip drill — Used for cleaning and reconditioning orifices (Figure O)

EXAMPLE:

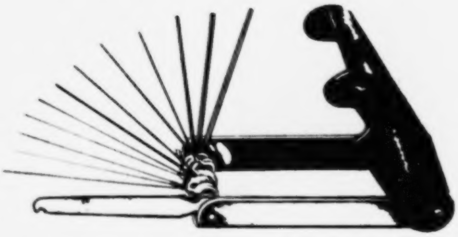
FIGURE O



2. Tip cleaner — A device with a series of small, file-like probes that are gauged to match specific orifice openings and are used to remove carbon build-up inside the tip (Figure P)

EXAMPLE:

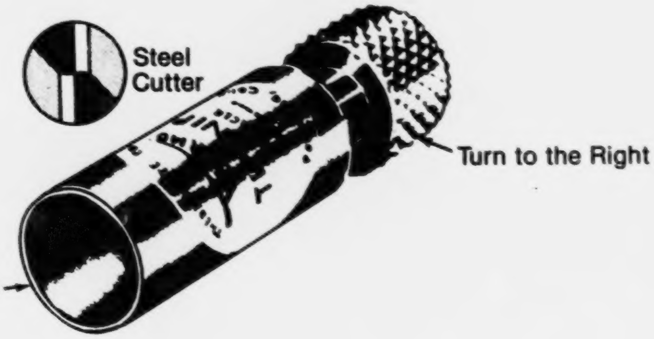
FIGURE P



3. Tip nip — A circular-shaped device with small steel cutting blades inset so it can be placed over the entire end of the tip to both clean and restore the face of the tip (Figure Q)

   EXAMPLE:

FIGURE Q



E. Rules for tip use

   1. Never use a tip as a hammer to chip off slag from a cut
   2. Never try to clean a tip by rubbing it on fire brick or against anything not designed for tip cleaning
   3. Never use an oily or greasy wrench to tighten a cutting tip, and never use an oily rag to clean dirt from a tip

F. Metal preparation for oxyacetylene cutting

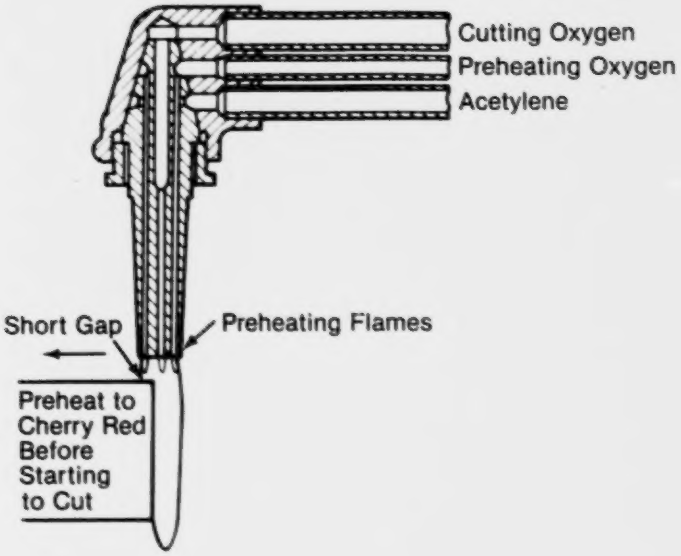
   1. For all critical cutting that requires following layout lines, metal should be burned free of oil and grease
   2. Scale and rust should be removed with a wire brush

G. Steps for properly starting a cut

   1. Place the cutting tip so that the preheat flame is half on the metal and half off the edge of the metal and the tip is perpendicular to the metal surface (See Figure R)

EXAMPLE:

FIGURE R


Cutting Oxygen
Preheating Oxygen
Acetylene
Short Gap
Preheating Flames
Preheat to Cherry Red Before Starting to Cut

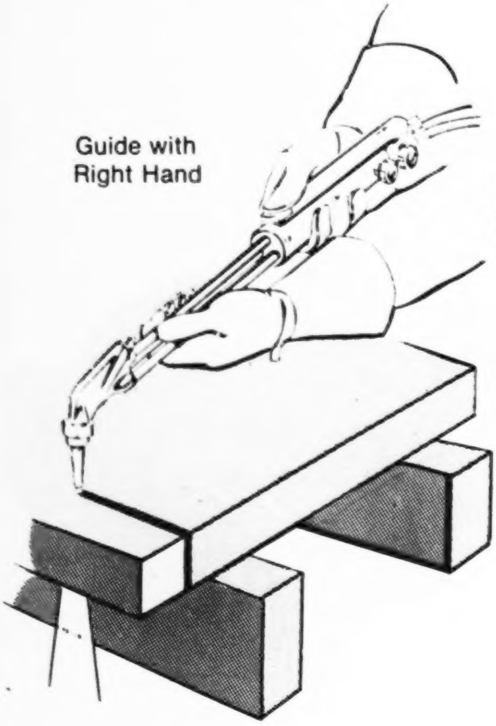
Reproduced by permission of the American Welding Society from AWS C4.2-78, *Operator's Manual for Oxyfuel Gas Cutting*.

2. The tips of the inner cones should be as close as possible to the metal without touching it
3. Preheat starting point until metal is cherry red, then slowly depress the oxygen cutting lever
4. When cutting starts, tilt the cutting tip slightly in the direction of the cut and move the tip at a constant speed along the cut line

H. Basic technique for cutting straight line (Figure S)

EXAMPLE:

FIGURE S



Used with permission of Modern Engineering Company, Inc.

1. Hold the torch in your right hand with your thumb on the cutting lever and the torch centered in front of your body
2. Support the torch in your left hand with a relaxed grip that will permit the torch to be turned
3. As you move the torch along the cutting line, roll your left hand slightly to the left from time to time to make the adjustment required to keep the cutting flame straight along the line

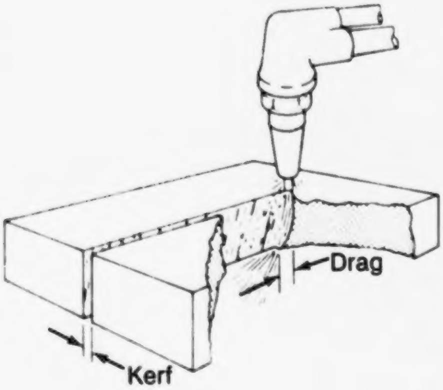
   (NOTE: The slight rolling technique with the left hand is the secret to good, straight cuts, so make some dry runs until you get the feel of it.)

I. Guidelines for controlling kerf and drag

1. Good oxyacetylene cutting should produce a clean kerf with minimum drag, and this requires proper tip selection, travel speed, and proper fuel gas pressures (See Figure T)

EXAMPLE:

FIGURE T



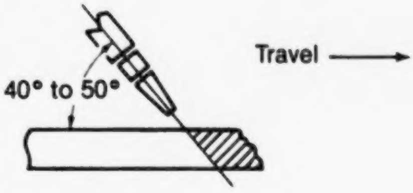
Reproduced by permission of the American Welding Society from AWS C4.2-78, *Operator's Manual for Oxyfuel Gas Cutting*.

2. The thickness of the metal being cut should dictate tip selection and fuel gas pressures, but cutting torch angle is also important for a clean cut

   a. For plate thickness 1/4 inch and less, the torch should be angled about 40 to 50 degrees from the base metal surface (Figure U)

   EXAMPLE:

FIGURE U



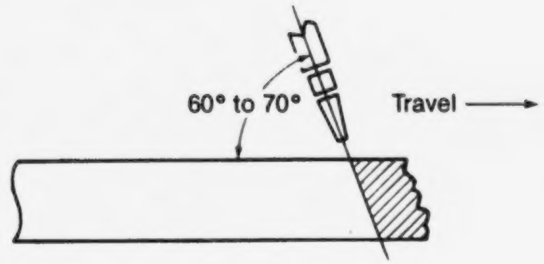
Reproduced by permission of the American Welding Society from AWS C4.2-78, *Operator's Manual for Oxyfuel Gas Cutting*.

   b. For plate thickness from 1/4 inch to 1/2 inch, the torch should be angled about 60 to 70 degrees from the base metal surface (See Figure V)

38

EXAMPLE:

FIGURE V

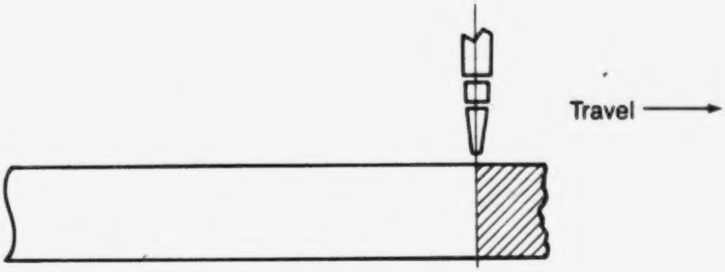


Reproduced by permission of the American Welding Society from AWS C4.2-78, *Operator's Manual for Oxyfuel Gas Cutting.*

c. For plate thickness over 1/2 inch, the torch should be held perpendicular to the plate (Figure W)

EXAMPLE:

FIGURE W



Reproduced by permission of the American Welding Society from AWS C4.2-78, *Operator's Manual for Oxyfuel Gas Cutting.*

J. Major causes of poor oxyacetylene cutting

1. Improper tip selection
2. Speed too slow or too fast
3. Tip and torch angles incorrect
4. Preheat flame too far from workplace
5. Working pressures incorrectly set

6. Oxygen cutting lever not fully depressed

7. Incorrect flame adjustment

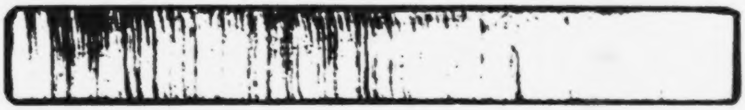
8. Cutting tip orifices clogged with slag or dirt

K. Elements of good cut (Figure X)

(NOTE: The following illustration shows a proper cut made in a steel plate approximately 1 inch thick and should be referenced for comparison with the cuts shown in the following examples.)

EXAMPLE:

FIGURE X



1. Edge is square

2. Drag lines are vertical and clean

3. No adhering slag at bottom edge of the cut

L. Reasons for poor cuts

1. Preheat flames were not hot enough for this cut with the result that the cutting speed was too slow, causing bad gouging at the bottom (Figure Y)

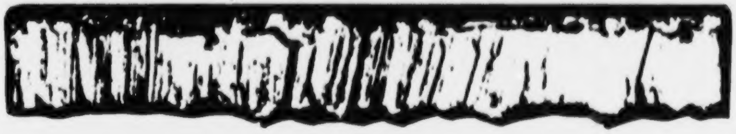
EXAMPLE:

FIGURE Y

2. Preheat flames were too hot with the result that the top surface has melted over, the cut edge is irregular, and there is an excessive amount of adhering slag (Figure Z)

   EXAMPLE:

FIGURE Z



3. Oxygen pressure was too low with the result that the top edge has melted over because of the slow cutting speed (Figure AA)

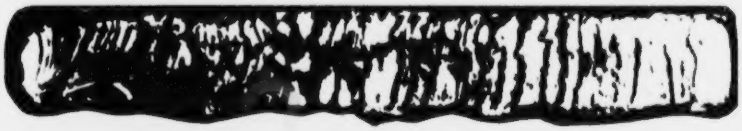
   EXAMPLE:

FIGURE AA

4. Oxygen pressure was too high and the nozzle size too small with the result that the entire control of the cut has been lost (Figure BB)

   EXAMPLE:

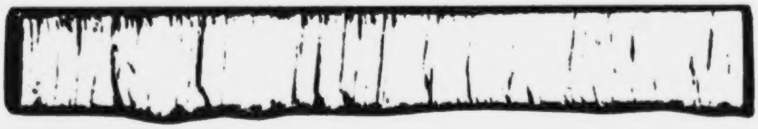
FIGURE BB



5. Cutting speed was too slow with the result that the irregularities emphasized (Figure CC)

   EXAMPLE:

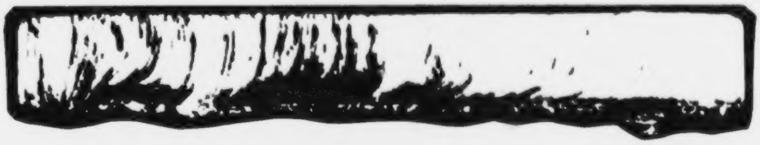
FIGURE CC



6. Cutting speed was too high with the result that there is a pronounced break to the dragline and the cut edge is irregular (Figure DD)

   EXAMPLE:

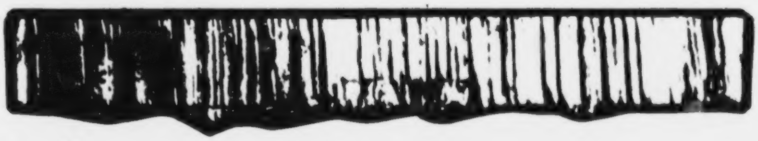
FIGURE DD



7. Torch travel was unsteady with the result that the cut edge is wavy and irregular (Figure EE)

   EXAMPLE:

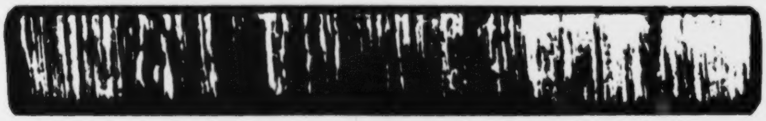
FIGURE EE



8. Cut was lost and not carefully restarted with the result that bad gouges were caused at the restarting point (Figure FF)

   EXAMPLE:

FIGURE FF



M. Eye protection required for oxyacetylene cutting

1. Wear safety glasses when cleaning or chipping base metal
2. Wear safety glasses and a face shield when grinding joints or bevels
3. Wear welding and cutting goggles to protect eyes from spatter, and choose goggles with a lens shade dark enough to protect eyes from radiation burns (Table A)

   EXAMPLE:

TABLE A: Appropriate lens shades

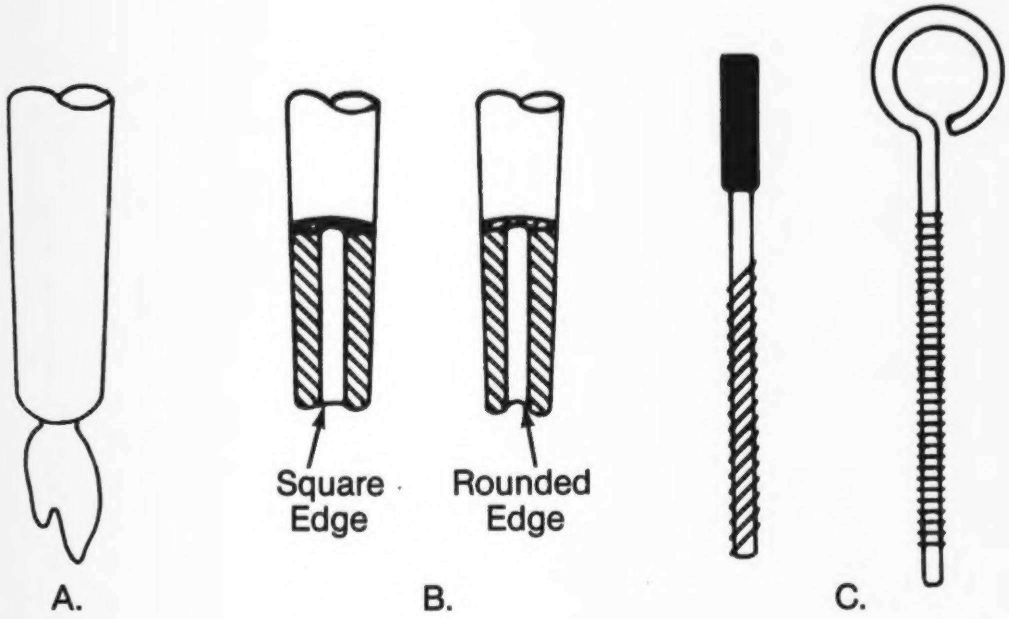
| Type of cutting | Metal thickness | Shade # |
|---|---|---|
| Light | Up to 1" | 3 or 4 |
| Medium | 1-6" | 4 or 5 |
| Heavy | 6" + | 5 or 6 |

Instructional Supplement #5 used with permission of Mid-America Vocational Curriculum Consortium, Stillwater, Oklahoma.

AIRFRAME
A204 AIRCRAFT WELDING
PERFORM GAS WELDING AND CUTTING
A204-A

INSTRUCTIONAL SUPPLEMENT #6

# Reconditioning Tips



A. Flame Made by a Tip in Need of Cleaning

B. The Edges of the Orifice Should Be Square—Not Rounded

C. Two Types of Cleaners

NOTE: Always Use the Right Size Cleaner

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AIRFRAME
A204 AIRCRAFT WELDING
PERFORM GAS WELDING AND CUTTING
A204-A

## TECHNICAL INFORMATION SUPPLEMENT #1 — Terms And Definitions Related to Gas Welding

A. Ultraviolet rays — Invisible rays of light which occur outside the violet end of the visible spectrum

(NOTE: These rays can damage organic material, i.e. eyes, skin.)

B. Reactive metal — Metal such as aluminum or magnesium which reacts with oxygen to form corrosion

C. Slag — A more or less completely fused and vitrified matter which separates from a metal in the process of its reduction in the melting furnace

D. Purge — To cleanse a system by flushing

E. Fusion welding — Joining pieces of metal by heating the adjoining edges to the fusion or melting point and allowing them to flow or run together and then cool

F. Flux — Material used to cover the pool of molten metal in the process of welding

(NOTE: The flux excludes oxygen from the weld by forming oxides which remain on the surface.)

G. Backfire — Momentary burning back of the flame into the tip

H. Flashback — Fire inside torch

**WARNING**

**This is a very dangerous condition.**

I. Infrared rays — Thermal radiation of wavelengths longer than those of visible light

(NOTE: Infrared rays could cause injury due to intense heat.)

J. Penetration — Distance from the original surface of the base metal to that point at which fusion ceases

K. Coefficient of expansion — Dimensionless number relating to the amount of dimensional change of a material with a change in temperature

L. Fillet — Concave junction formed where two surfaces meet

(NOTE: This concave junction is formed by welding processes.)

M. Base metal — Metal being welded

N. Alloy — Mixture with metallic properties composed of two or more elements of which one is a metal

O. Inner cone — Inner white part of the neutral flame

P. Tack weld — Short weld used for temporarily holding material in place

Q. Oxide — Term usually applied to rust, corrosion, coating, film, or scale

(NOTE: Oxygen combines with the metal causing oxides.)

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PERFORM GAS WELDING AND CUTTING
A204-A

## TECHNICAL INFORMATION SUPPLEMENT #2 — Safety Rules for Handling Oxygen, Acetylene, and Oxyacetylene Welding and Cutting Equipment

A. Support oxygen and acetylene cylinders in an upright position so they cannot be tipped over

(NOTE: Acetylene gas is in a liquid state in the cylinder, and cylinders should be in a vertical position when used in order that acetone will not be withdrawn.)

B. Blow out cylinder valves (crack cylinder valves for a second before attaching regulators) in order to remove dust and dirt that may damage regulators

C. Release pressure adjusting screw on regulator before opening cylinder valve in order to prevent damage to regulators and possible injury to operator

D. Stand to the side of regulators, keeping the cylinder valve between operator and regulator, when opening cylinder valves

E. Open cylinder valves slowly

F. Do not use acetylene (in free state) at pressures higher than 15 psi

(NOTE: Acetylene becomes unstable at pressures above 15 psi and becomes highly explosive.)

G. Purge oxygen and acetylene passages (individually) before lighting torch

H. Light acetylene before opening oxygen torch valve

I. Never use oil or grease on regulators, torches, or fittings

**WARNING**

**Do not use any equipment if grease or oil is detected on any surfaces. Oil or grease and oxygen have a great affinity for one another and will unite with explosive violence.**

J. Do not use oxygen as a substitute for compressed air

K. Use safety goggles, gloves, and protective clothing

L. Have $CO_2$ or dry-powder-type fire extinguisher available

M. Test connections for leaks with Ivory soapsuds, paintbrush, and water

N. Avoid lighting torch, cutting, or welding near combustible materials

O. Never open the acetylene cylinder valve more than one-half to three-quarters of a turn

P. Always operate torch in a well-ventilated area

Q. Never cut containers that have been used for combustible materials

R. Avoid breathing toxic fumes when cutting or welding

(NOTE: Cutting or welding galvanized metal produces toxic fumes.)

S. Place steel caps on all gas cylinders when they are being moved or stored to protect the valves

T. Shut off cylinder valves when not in use for any length of time to reduce the possibility of leakage and strain on the equipment

U. Turn off oxygen torch valve first

V. Keep hands, gloves, and clothing free from oil and grease

W. Never cut or weld too close to concrete (masonry)

X. Always weld or cut at least five feet from cylinders

Y. Always protect hoses from hot metal, rupture, or mechanical damage

Z. Always light torch with a friction lighter

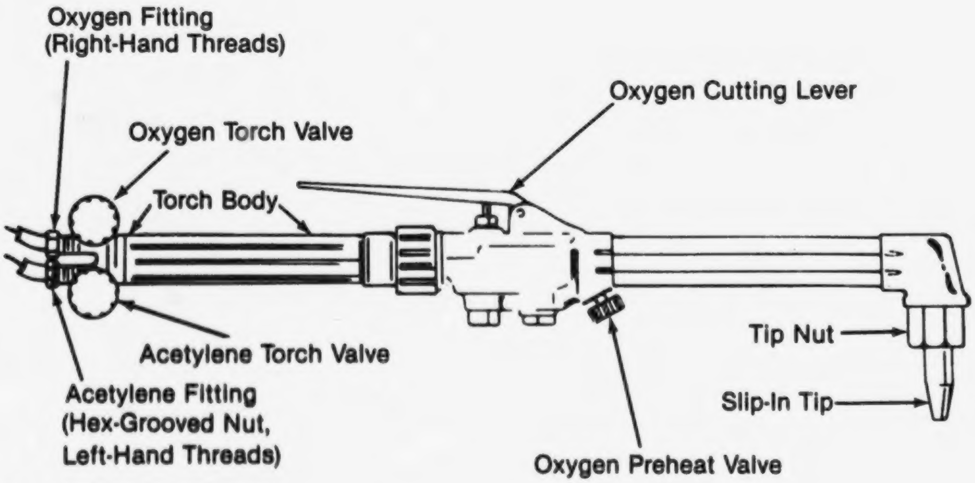
AA. Never leave a burning torch unattended

## TECHNICAL INFORMATION SUPPLEMENT #3 — Fundamentals of Cutting and Welding

A. Parts of a cutting torch and tip

1. Cutting torch (Figure 1)

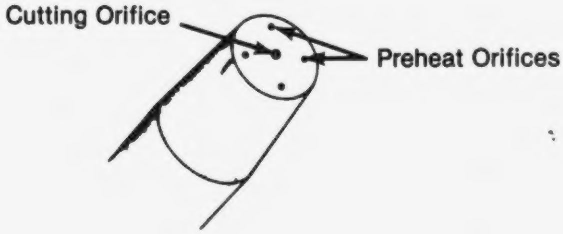
FIGURE 1


Oxygen Fitting
(Right-Hand Threads)
Oxygen Cutting Lever
Oxygen Torch Valve
Torch Body
Tip Nut
Acetylene Torch Valve
Acetylene Fitting
(Hex-Grooved Nut,
Left-Hand Threads)
Slip-In Tip
Oxygen Preheat Valve

2. Cutting tip (Figure 2)

(NOTE: The selection of the correct tip for the job is determined by the thickness of metal, size of the tip orifices, and the oxygen cutting pressures. See manufacturer's recommendations. This applies to both welding and cutting.)

FIGURE 2


Cutting Orifice
Preheat Orifices

        a. Preheat orifice — Heats metal to kindling point (cherry red) or approximately 1600°F

        b. Cutting orifice — Removes oxidized metal

B. Causes of a backfire

(NOTE: The following items should be carefully checked to control backfire.)

1. Insufficient acetylene or oxygen pressure
2. Loose torch tip
3. Dirty tip
4. Overheating of cutting tip
5. Bad O-ring in torch body

C. Results of a backfire

1. Flame burns momentarily back into tip
2. A loud snap or pop results
3. Flame may go out
4. Flame may continue to burn in normal manner

D. Results of flashback

1. Fire inside torch
2. Disappearance of flame followed by
    a. Squealing or hissing noise inside torch
    b. Sparks coming from the torch
    c. Smoke coming from the torch

E. Steps to follow if flashback occurs

**WARNING**

**A flashback means something is terribly wrong.**

## TECHNICAL INFORMATION SUPPLEMENT #3

1. Do not panic
2. Close oxygen preheat valve

   (NOTE: This step only applies to the cutting torch.)

3. Close oxygen torch valve
4. Close acetylene torch valve

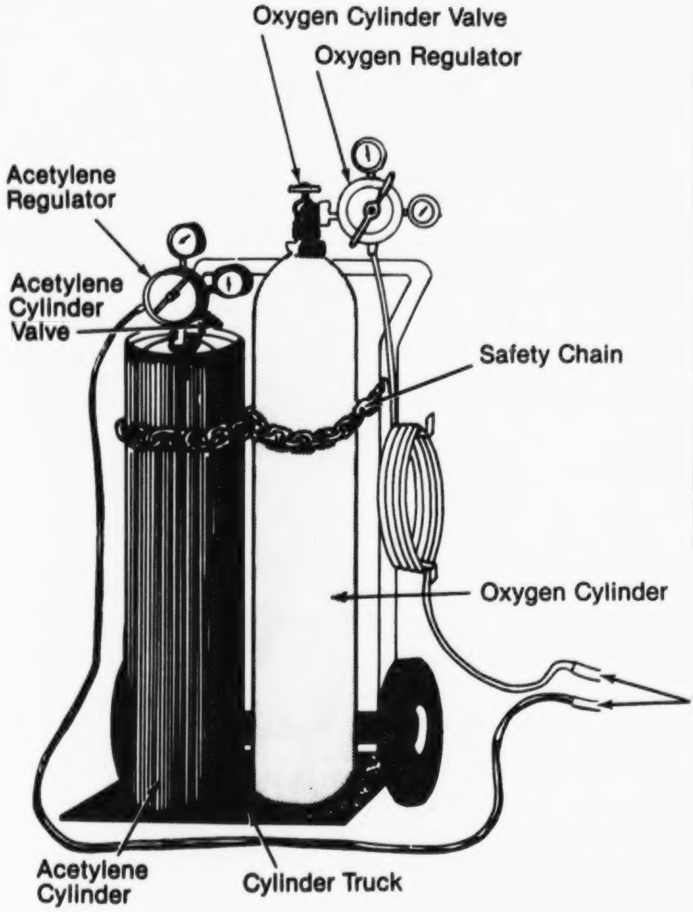
**WARNING**

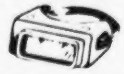
**The next steps are accomplished if the operator determines that there is time to do them.**

5. Shut off oxygen cylinder valve first and then the acetylene cylinder valve unless you see the hose flame heading right for the acetylene cylinder; if it is, *you* will have to *quickly* decide either to turn off the cylinder valve or to run
6. Disassemble, inspect, and replace any damaged equipment before relighting

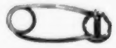
F. Oxyacetylene welding equipment (Figure 3)

FIGURE 3

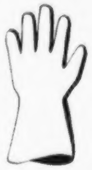

Oxygen Cylinder Valve
Oxygen Regulator
Acetylene Regulator
Acetylene Cylinder Valve
Safety Chain
Oxygen Cylinder
(Hoses to Torch)
Acetylene Cylinder
Cylinder Truck



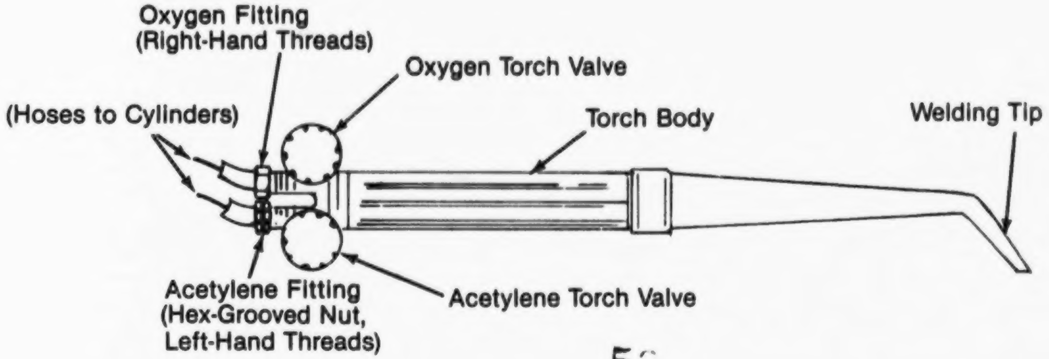
Welding Goggles



Flint Lighter



Welding Gloves


Oxygen Fitting (Right-Hand Threads)
Oxygen Torch Valve
(Hoses to Cylinders)
Torch Body
Welding Tip
Acetylene Fitting (Hex-Grooved Nut, Left-Hand Threads)
Acetylene Torch Valve

## TECHNICAL INFORMATION SUPPLEMENT #3

G. Lens shades (Table 1)

(NOTE: Wear welding goggles or a welding hood with the proper lens shade for all welding and cutting activity.)

EXAMPLE:

TABLE 1: Lens-shade selector

| Type of operation | Shade number |
|---|---|
| Soldering | 2 |
| Torch brazing | 3 or 4 |
| Oxygen cutting | |
| Base-metal thickness | |
| 0 to 1 inch | 3 or 4 |
| 1 to 6 inches | 4 or 5 |
| 6 inches and over | 5 or 6 |
| Gas welding | |
| Base-metal thickness | |
| 0 to 1/8 inch | 4 or 5 |
| 1/8 to 1/2 inch | 5 or 6 |
| 1/2 inch and over | 6 or 8 |
| Shielded metal arc welding<br>1/16-, 3/32-, 1/8-, 5/32-inch electrodes | 9 to 14 |
| Gas metal arc welding | 9 to 14 |
| Gas tungsten arc welding (nonferrous), gas-metal arc welding (nonferrous)<br>1/16-, 3/32-, 1/8-, 5/32-inch electrodes | 9 to 14 |
| Gas tungsten arc welding (ferrous), gas-metal arc welding (ferrous)<br>1/16-, 3/32-, 1/8-, 5/32-inch electrodes | 9 to 14 |

(NOTE: In oxyacetylene welding and cutting, lens-shade requirements are based on metal thickness, but in gas-shielded arc welding, lens-shade requirements are based on electrode size, the amperage range of the electrode, and base-metal properties.)

H. Factors determining fusion weld quality

   1. Proper flame adjustment
   2. Angle of tip
   3. Distance from work
   4. Speed of travel
   5. Movement of tip

I. Properties of a good weld

   1. Consistent width
   2. Straightness
   3. Slightly crowned
   4. Fused into base metal
   5. Clean appearance

J. Factors determining tip size selection

(NOTE: Always use manufacturer's recommendations to determine tip size.)

   1. Metal thickness
   2. Size of welding rod

K. Factors determining rod selection

   1. Rod with similar properties as base metal
   2. Thickness of metal

      (NOTE: A general rule is to use a rod with a diameter equal to the thickness of the base metal.)

L. Purpose of filler rod — To add strength to weld or joint

M. Types of oxyacetylene flames and their characteristics (Table 2)

TABLE 2: Oxyacetylene flames

| Name | Characteristics | Uses |
|---|---|---|
| Oxidizing | Excess oxygen to acetylene burning ratio with no acetylene feather, and makes a harsh, hissing sound | Least used because it oxidizes metal, but is used for braze welding with a bronze rod |
| Neutral | Burns equal amounts of oxygen and acetylene, and has a clear, clean-edged inner cone | The most used flame for OAW applications |
| Reducing (Lightly carburizing) (Acetylene feather extends 2 times beyond neutral flame.) | Burns slightly more acetylene than oxygen, acetylene feather appears just beyond the point of the neutral flame, and is also a carburizing flame | Used for backhand welding and for welding mild steel with low-alloy rods |
| Carburizing (Acetylene feather extends 3 times beyond neutral flame.) | Excess acetylene to oxygen burning ratio with an acetylene feather two to three times the length of the inner cone | Used for some hardfacing, but must be used selectively because it adds carbon to base metals |

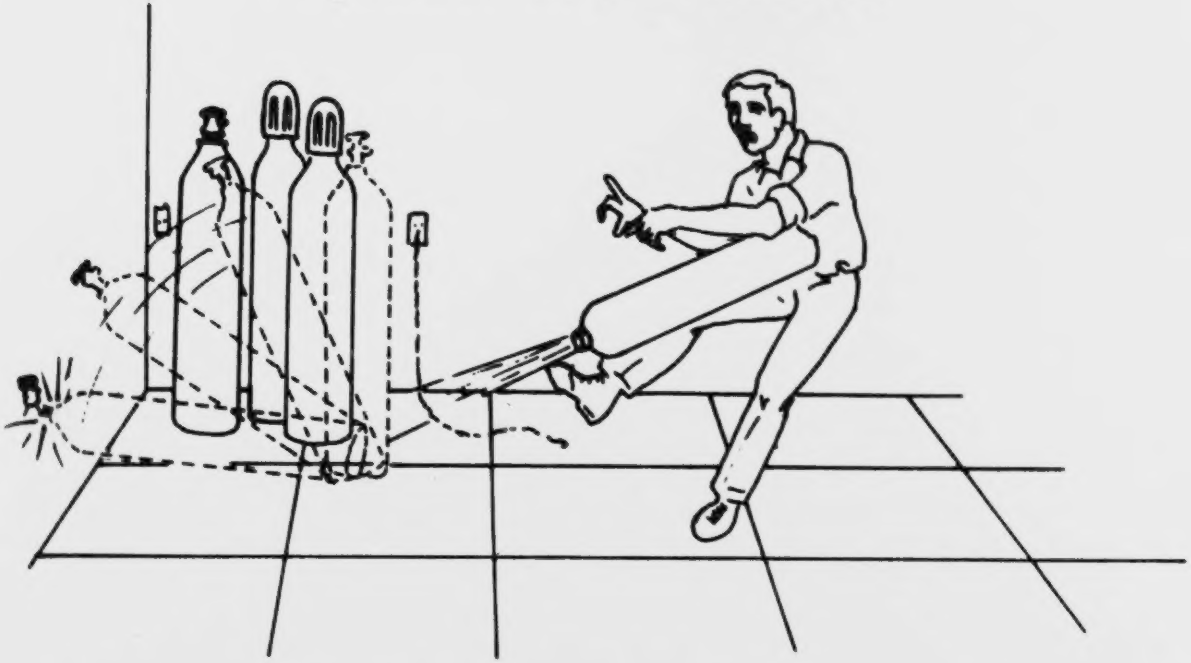
# Safety Meeting

**"Safety is for Sissies"**

To Promote the Safe Handling
of Oxy-Fuel Gas Equipment

Used with permission of Smith Welding Equipment Division, Tescom Corporation, Watertown, South Dakota.

# Cylinder into a Rocket



A Standard 250 Cu Ft Cylinder Pressurized to 2500 PSI Can, After a Cylinder Valve is Broken Off, Become a Rocket Attaining a Speed of 34 MPH in One-Tenth of a Second After Venting from the Broken Cylinder Connection.

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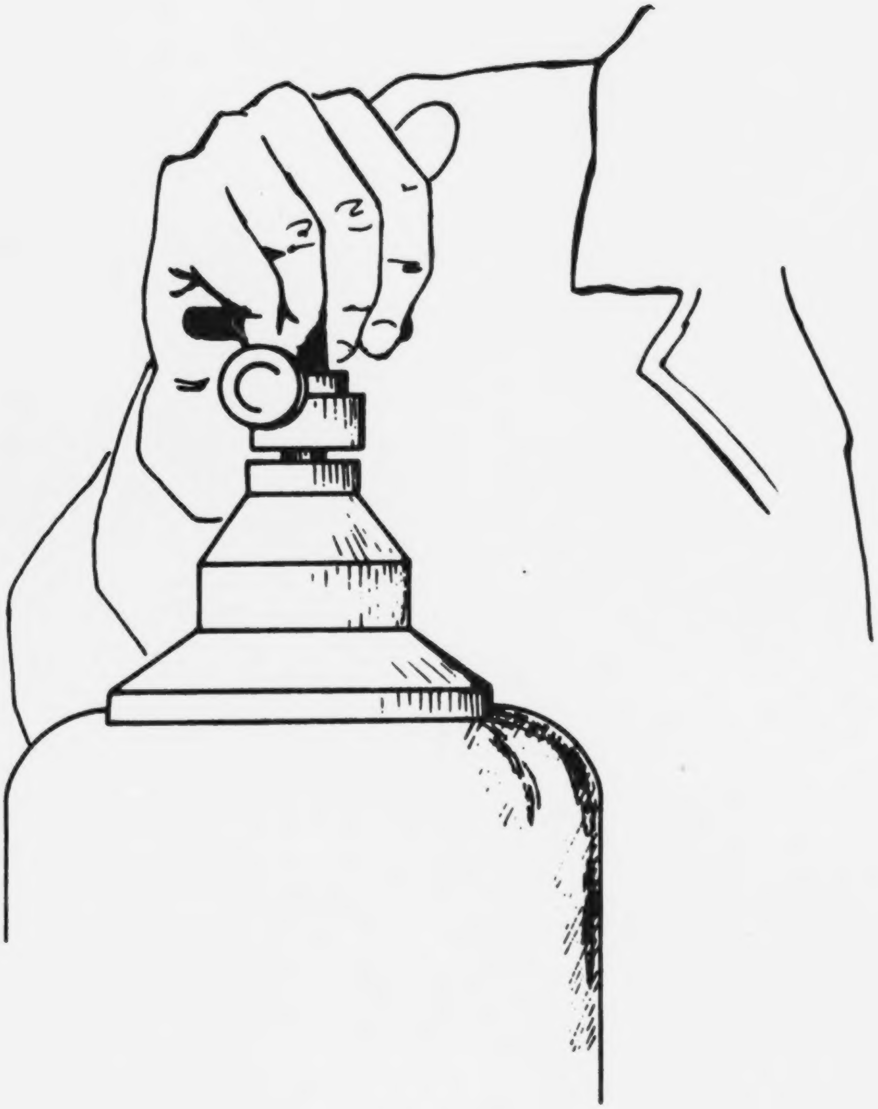
A204A-61

TM #2

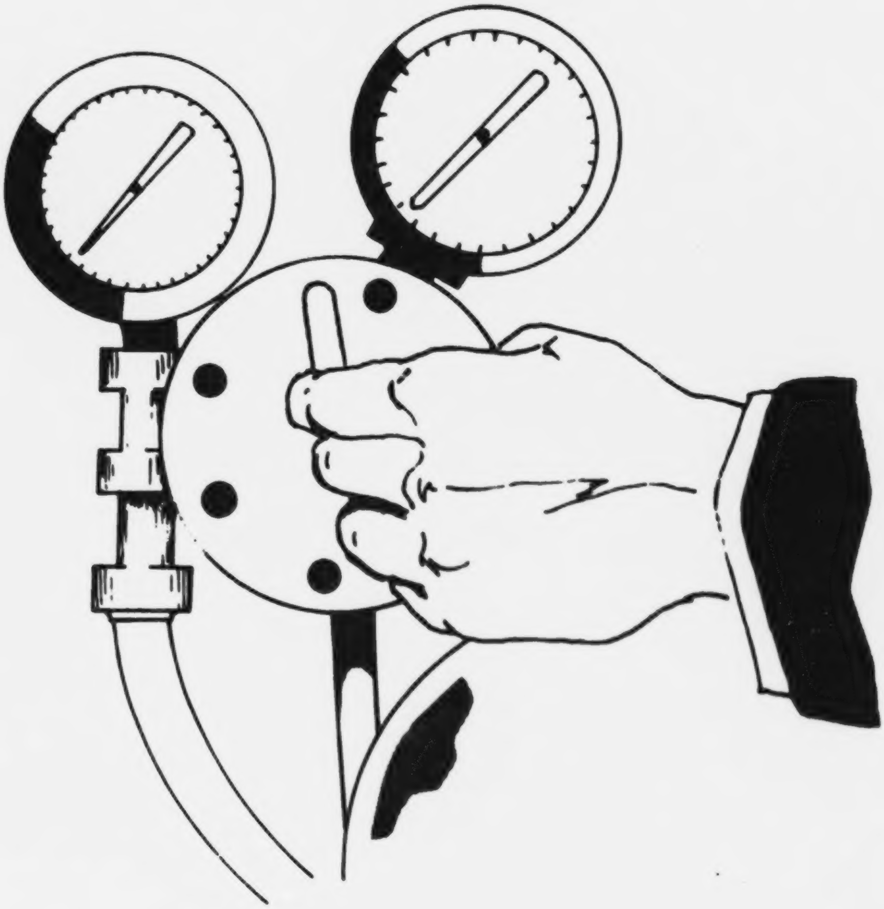
# Safety Rules



Blow Out Cylinder Valves Before Attaching Regulators.

Used with permission of Smith Welding Equipment Division, Tescom Corporation, Watertown, South Dakota.

# Safety Rules
## (Continued)



Release Adjusting Screw on Regulators Before Opening Cylinder Valves.

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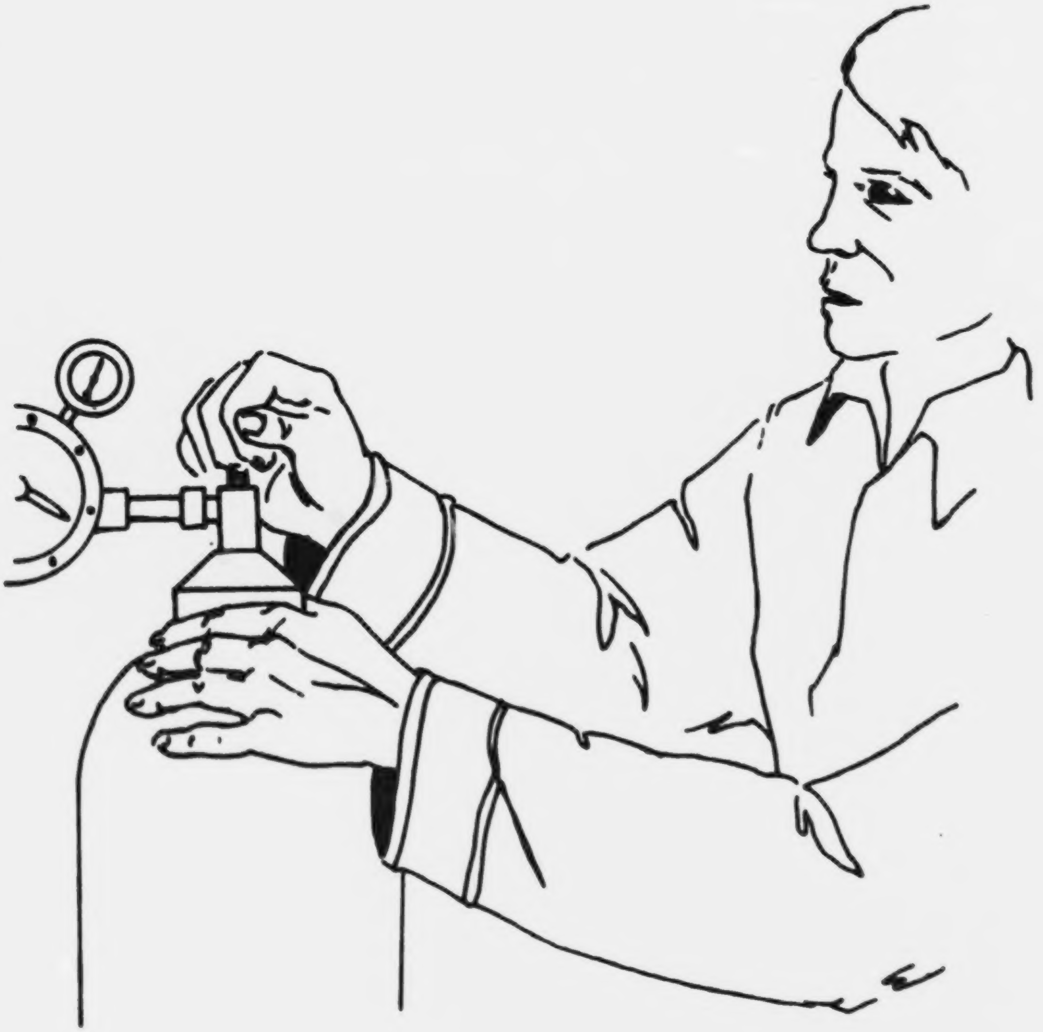
# Safety Rules
## (Continued)



Stand to One Side of Regulator When Opening Cylinder Valve.

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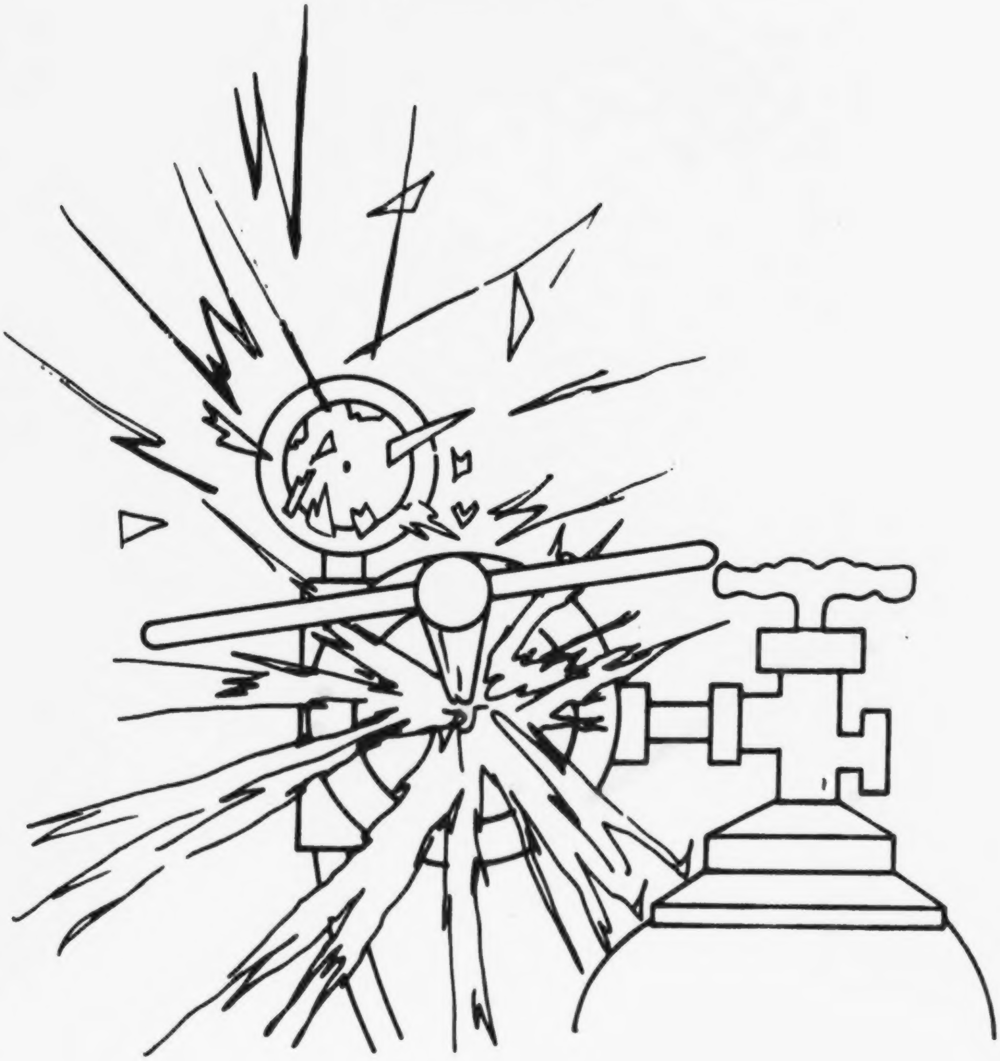
# Safety Rules
## (Continued)



Open Cylinder Valves S-L-O-W-L-Y.

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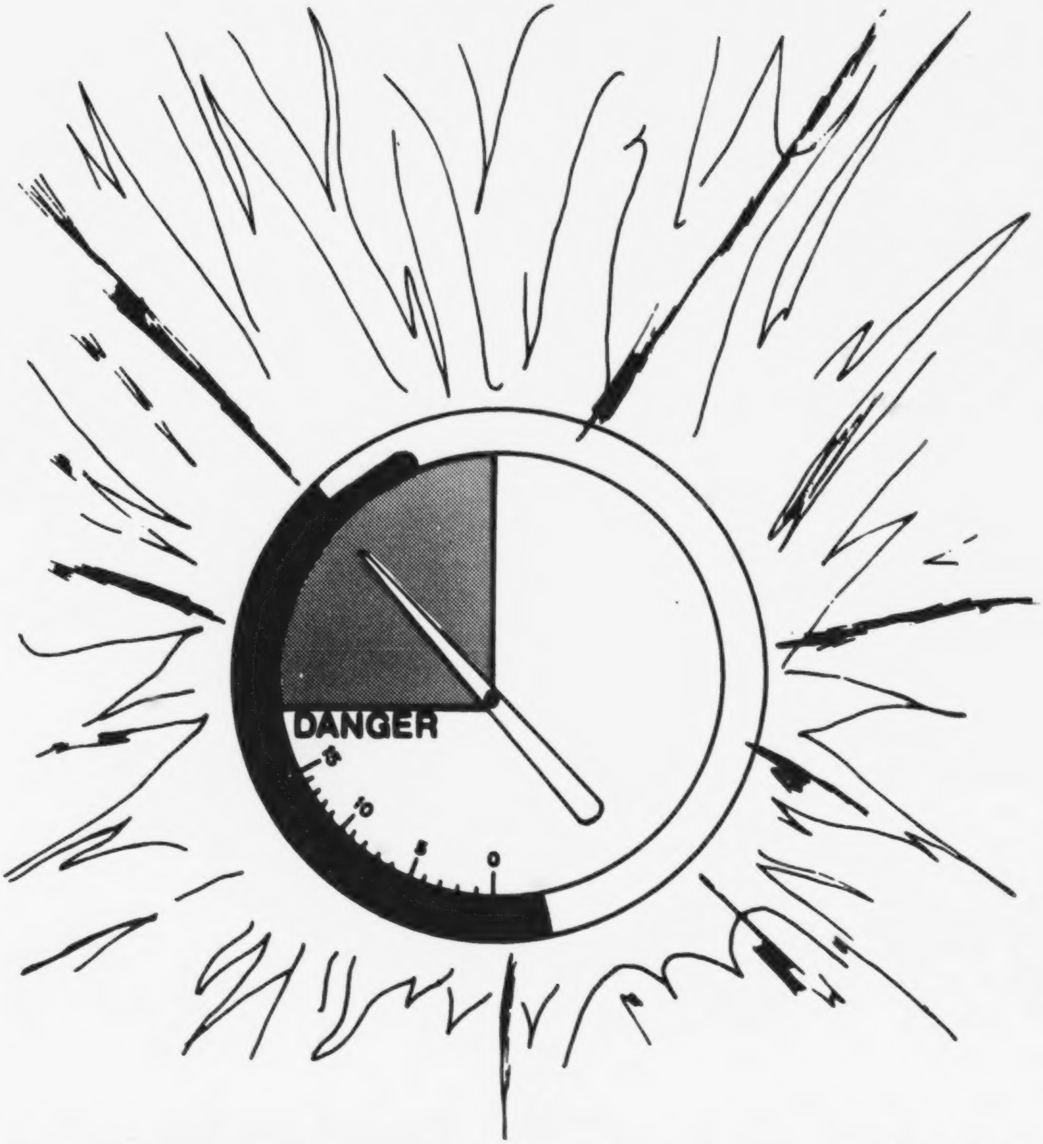
# Safety Rules
## (Continued)



Do Not Use or Compress Acetylene (in Free State) at Pressures Higher Than 15 PSI.

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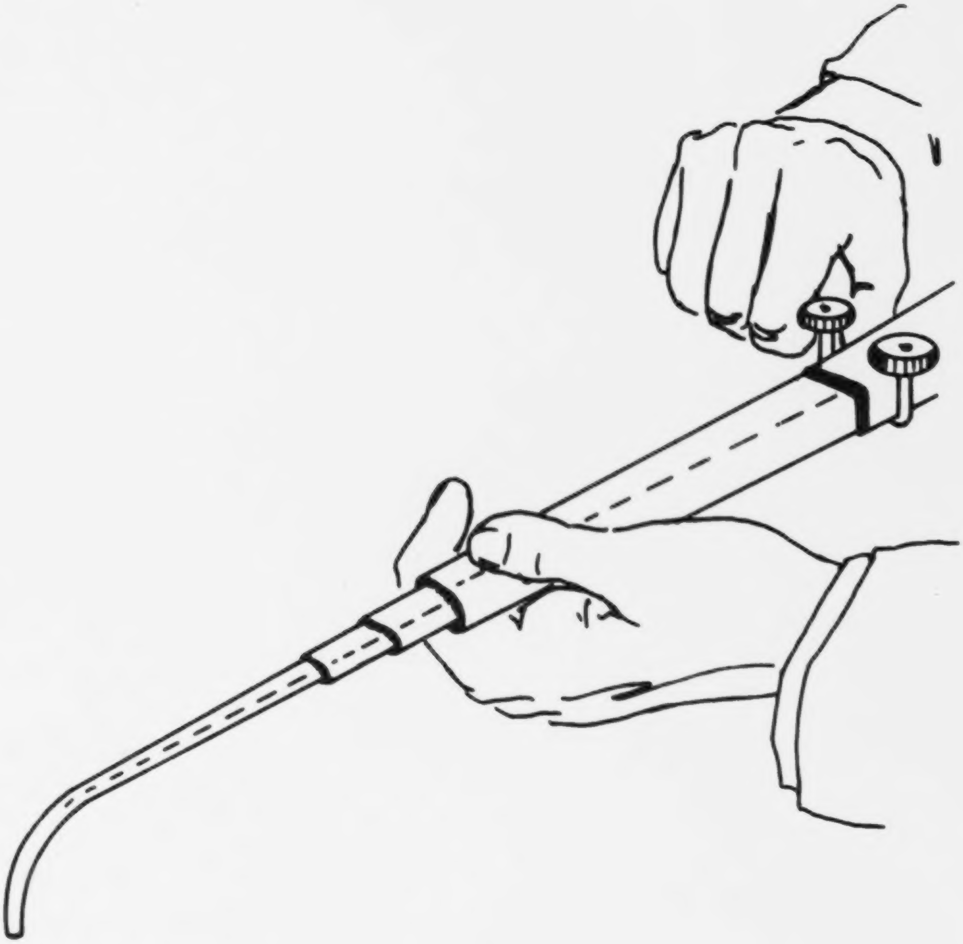
# Safety Rules
## (Continued)



Purge Oxygen and Fuel Gas Passages (Individually) Before Lighting Torch.

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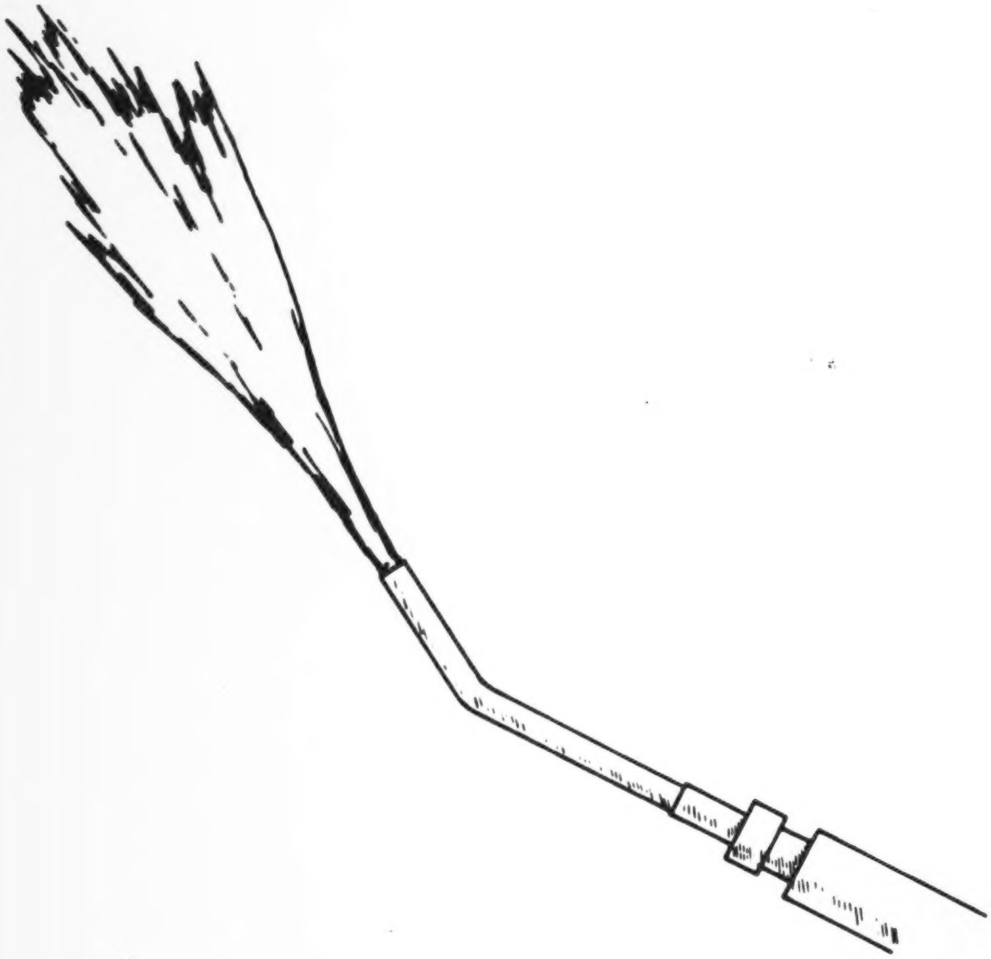
# Safety Rules
## (Continued)



Light Acetylene Before Opening Oxygen Valve on Torch.

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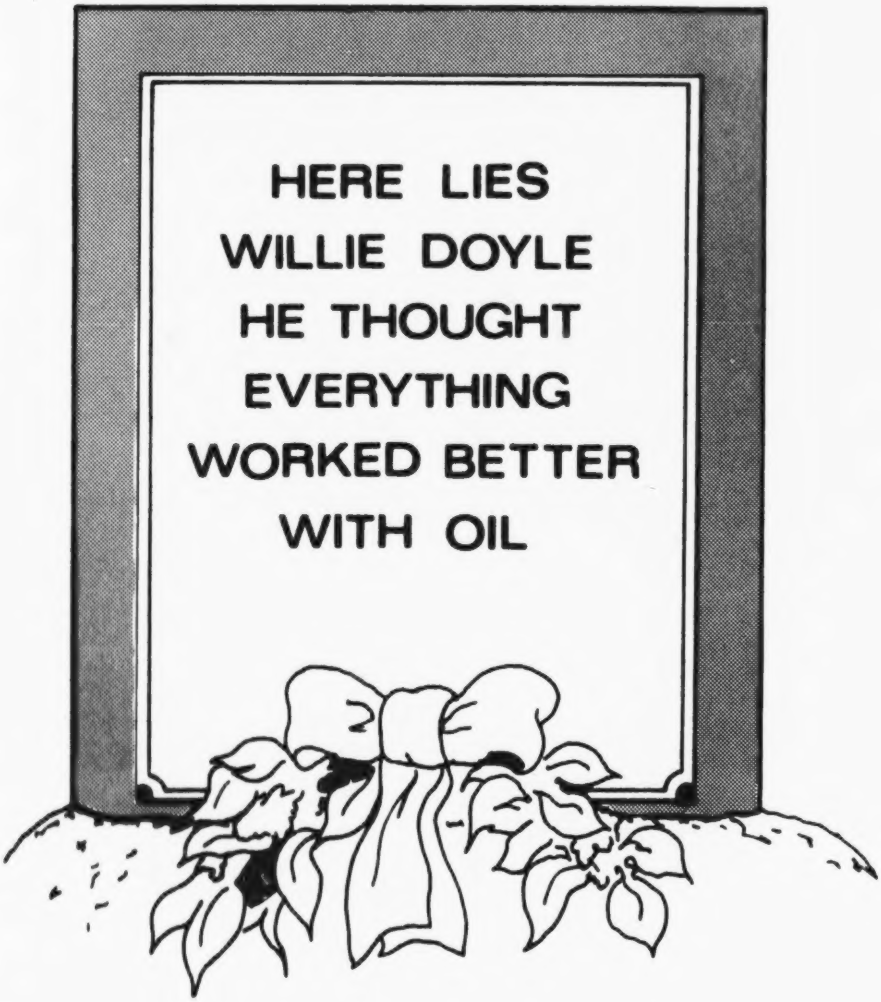
# Safety Rules

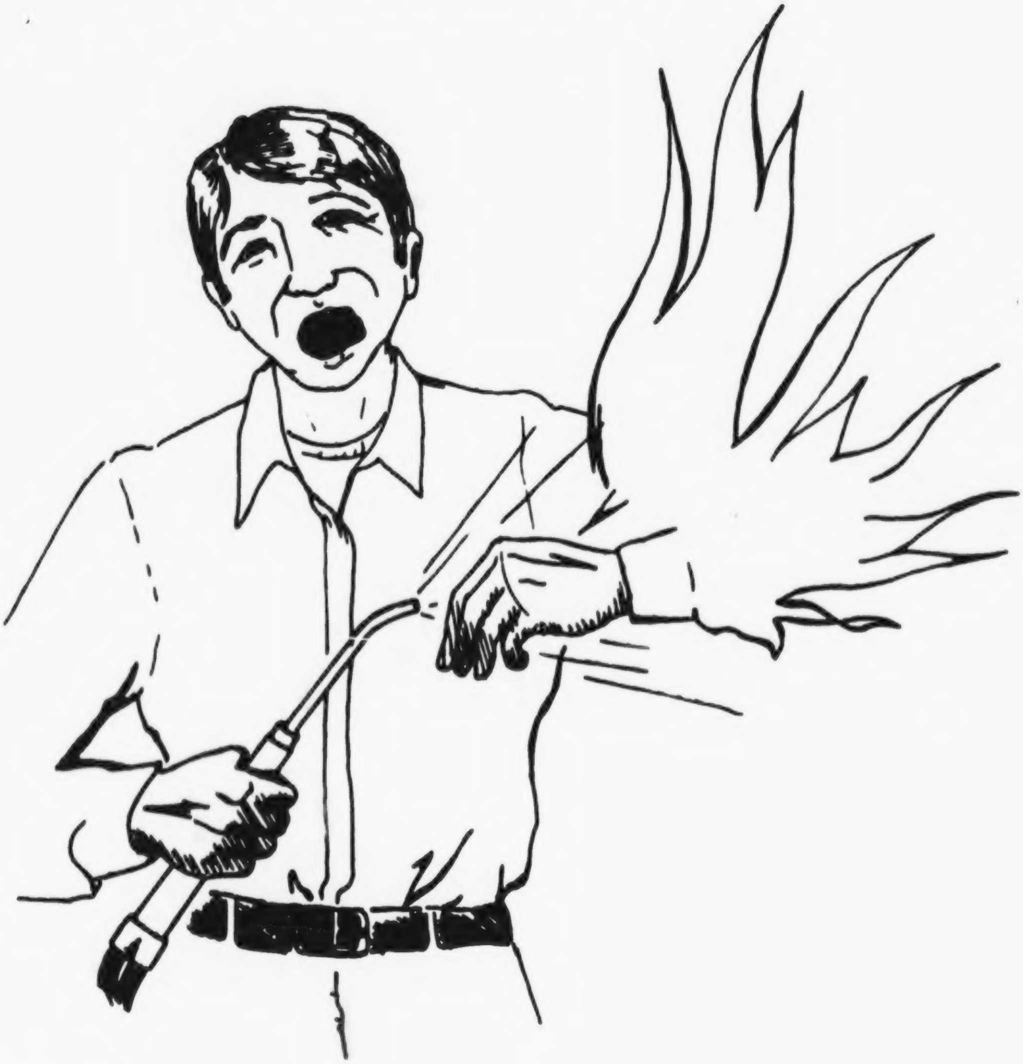
## (Continued)


HERE LIES
WILLIE DOYLE
HE THOUGHT
EVERYTHING
WORKED BETTER
WITH OIL

NEVER Use Oil on Regulators, Torches, Fittings or Other Equipment in Contact with OXYGEN.

Used with permission of Smith Welding Equipment Division, Tescom Corporation, Watertown, South Dakota.

# Safety Rules
## (Continued)



Do Not Use OXYGEN as a Substitute for Compressed AIR.

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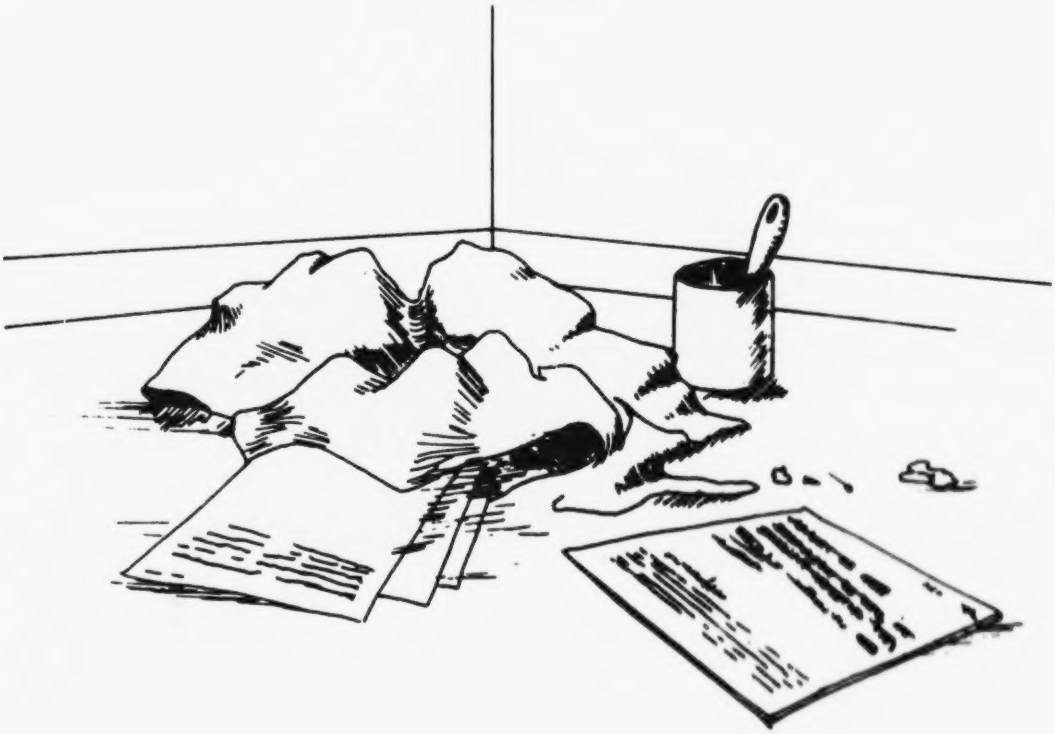
# Safety Rules

## (Continued)



Keep Heat, Flames and Sparks Away from Combustibles.

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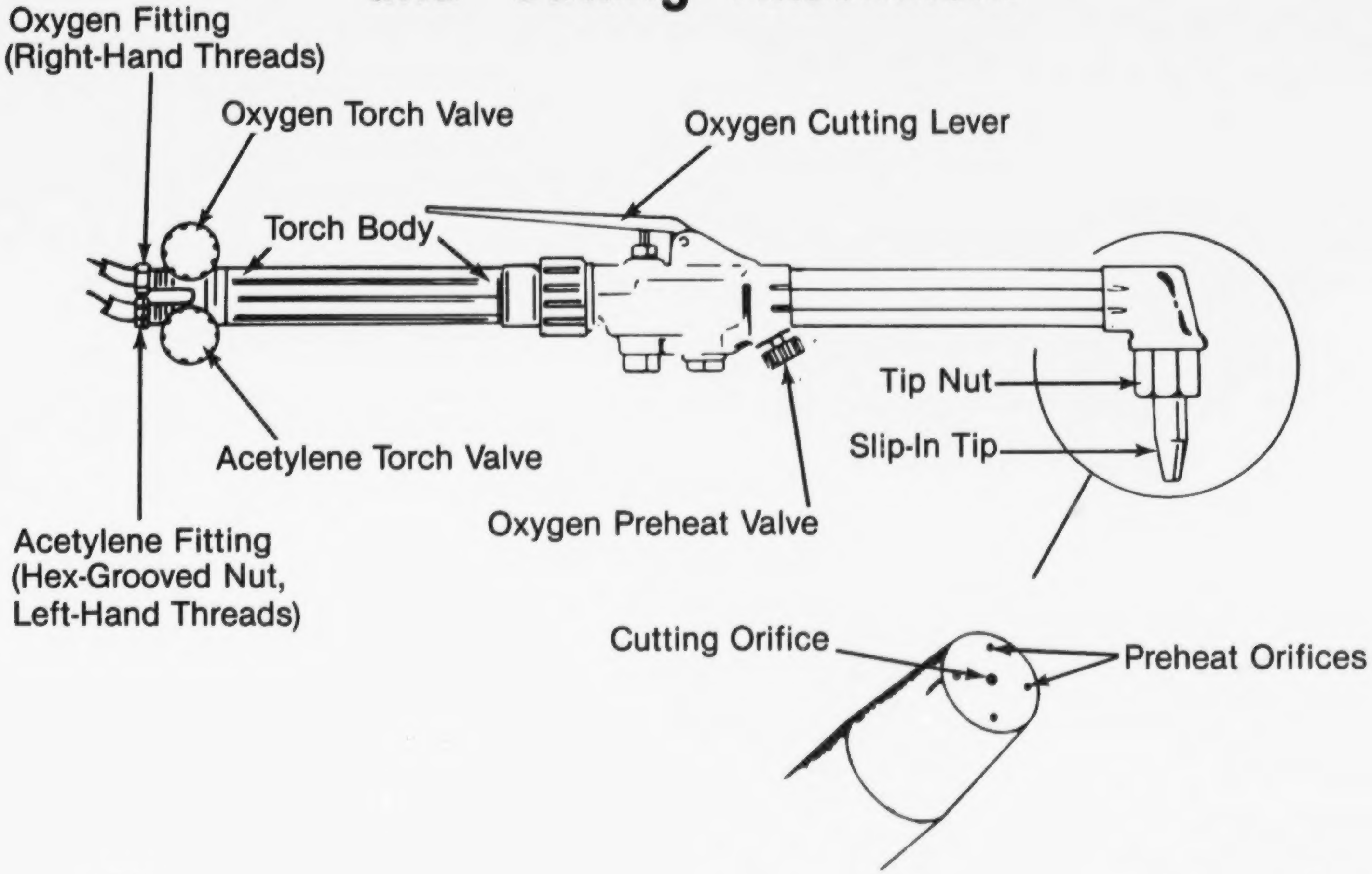
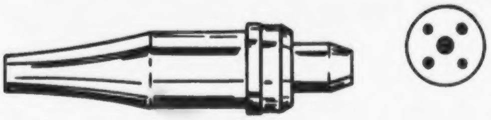
# Parts of a Torch Body and Cutting Attachment


Oxygen Fitting (Right-Hand Threads)
Oxygen Torch Valve
Oxygen Cutting Lever
Torch Body
Tip Nut
Slip-In Tip
Acetylene Torch Valve
Oxygen Preheat Valve
Acetylene Fitting (Hex-Grooved Nut, Left-Hand Threads)
Cutting Orifice
Preheat Orifices

A204A-83

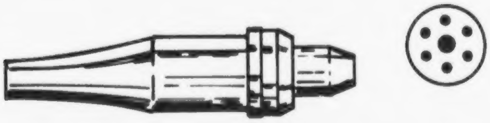
TM #13

# Typical Cutting Tips and Orifices



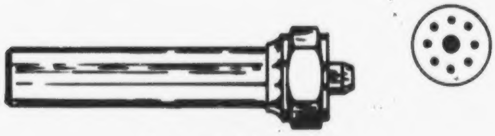
Acetylene

Light Preheat, Light Cutting



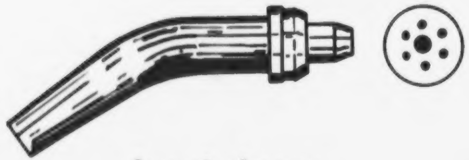
Acetylene

Medium Preheat, Light Cutting



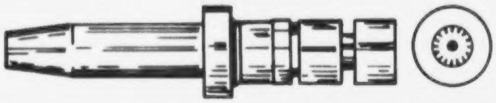
Acetylene

Heavy Preheat, Heavy Cutting



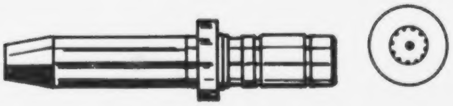
Acetylene

Medium Preheat, Gouging



Propane

General Purpose



Natural Gas (Methane)

General Purpose

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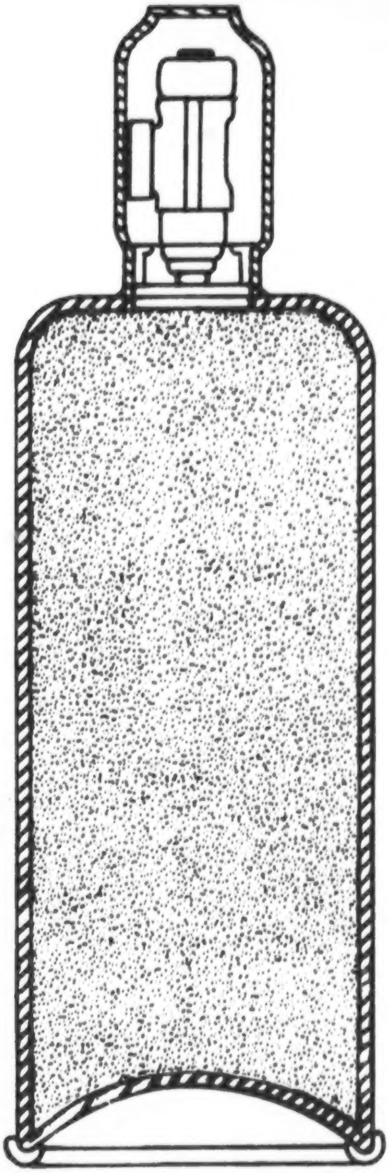
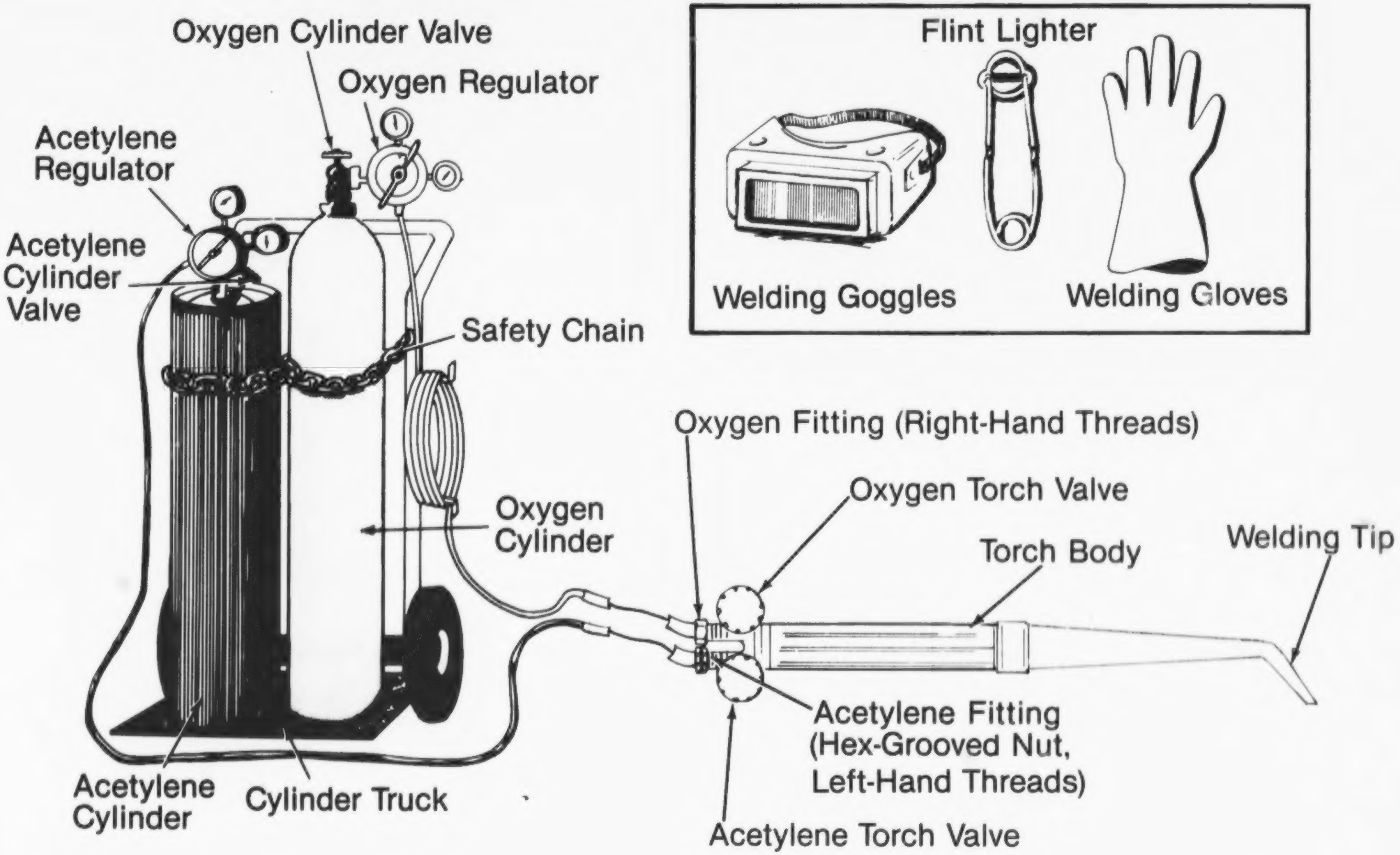
# Acetylene Cylinder



Cross-Section of Acetylene Bottle with Porous Filler Material.

Used with permission of Instructional Materials Laboratory, University of Missouri, Columbia, Missouri.

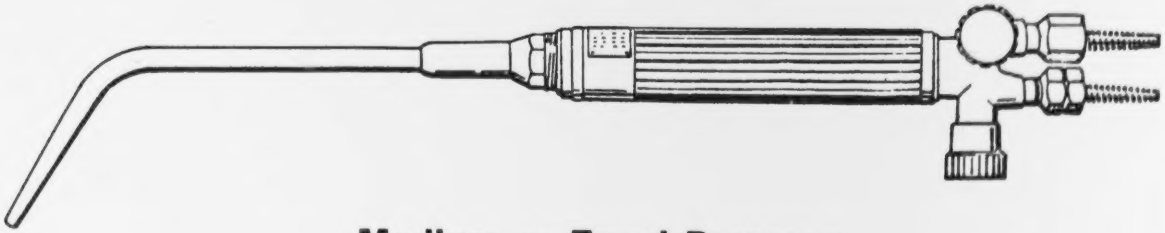
# Oxyacetylene Welding Equipment


Flint Lighter
Welding Goggles
Welding Gloves
Oxygen Cylinder Valve
Oxygen Regulator
Acetylene Regulator
Acetylene Cylinder Valve
Safety Chain
Oxygen Cylinder
Acetylene Cylinder
Cylinder Truck
Oxygen Fitting (Right-Hand Threads)
Oxygen Torch Valve
Torch Body
Welding Tip
Acetylene Fitting (Hex-Grooved Nut, Left-Hand Threads)
Acetylene Torch Valve

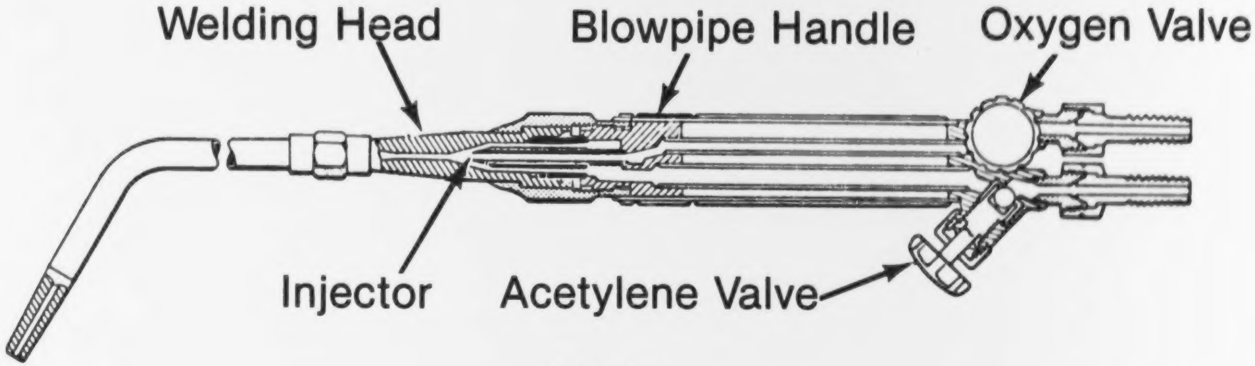
A204A-89

TM #16

# Welding Torches



Medium or Equal Pressure

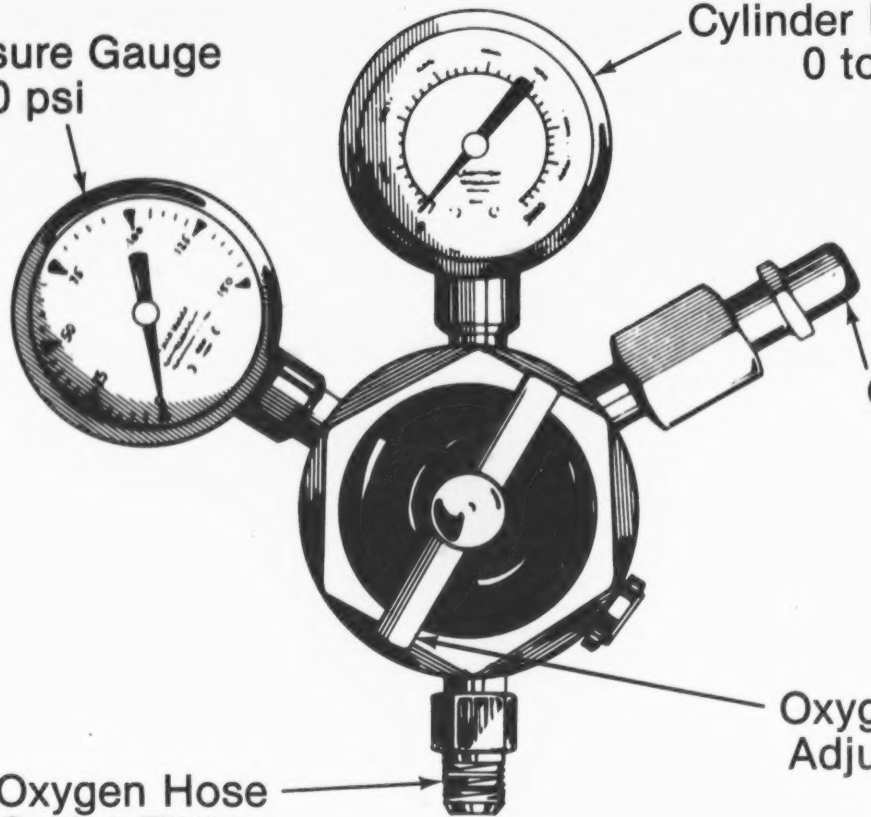

Welding Head
Blowpipe Handle
Oxygen Valve
Injector
Acetylene Valve

Injector

A204A-91

TM #17

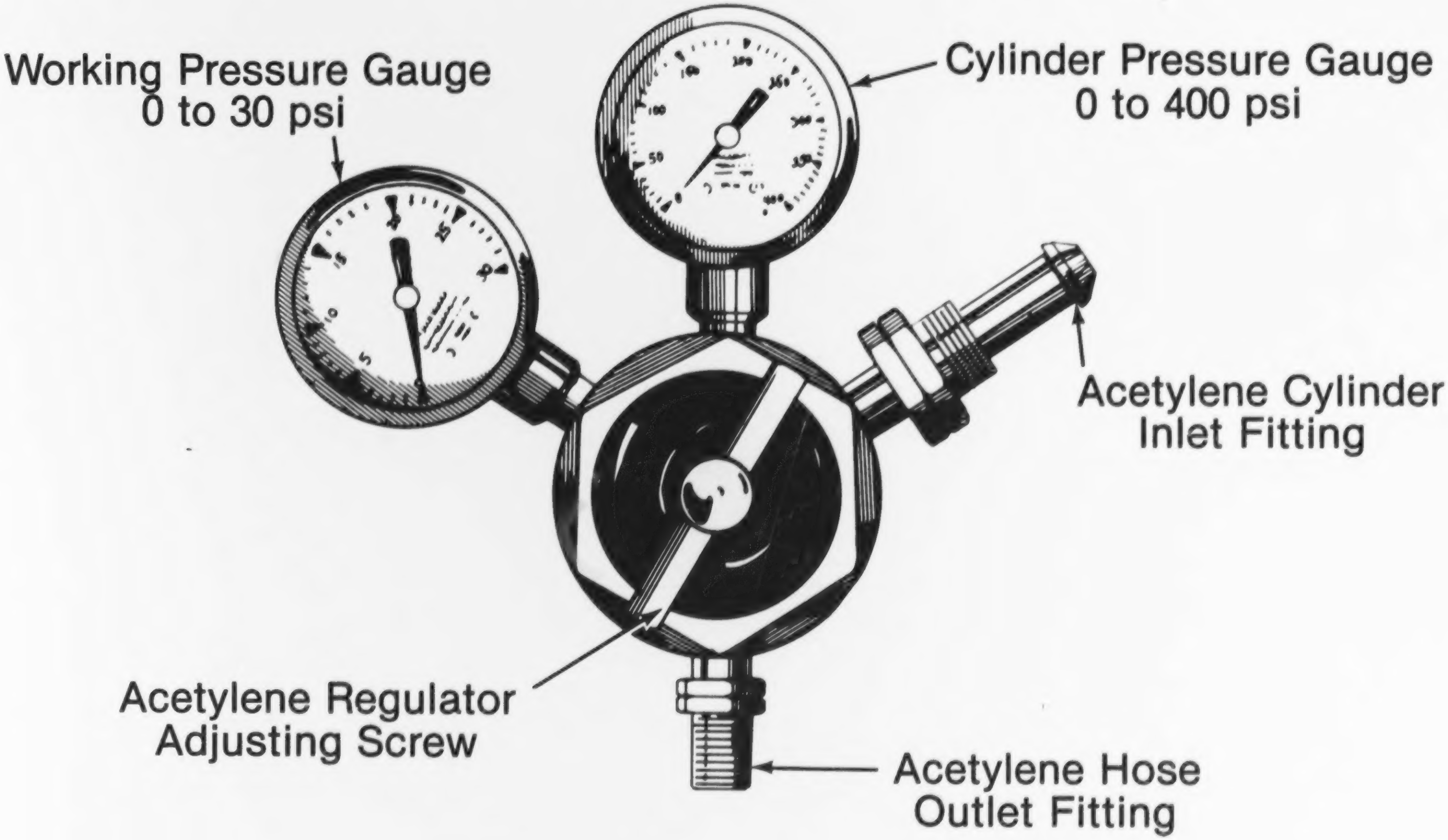
# Oxygen Regulator Gauges


Working Pressure Gauge
0 to 150 psi
Cylinder Pressure Gauge
0 to 3000 psi
Oxygen Cylinder
Inlet Fitting
Oxygen Regulator
Adjusting Screw
Oxygen Hose
Outlet Fitting

A204A-93

TM #18

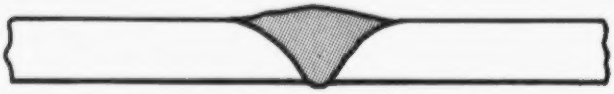
# Acetylene Regulator Gauges


Working Pressure Gauge
0 to 30 psi
Cylinder Pressure Gauge
0 to 400 psi
Acetylene Cylinder
Inlet Fitting
Acetylene Regulator
Adjusting Screw
Acetylene Hose
Outlet Fitting

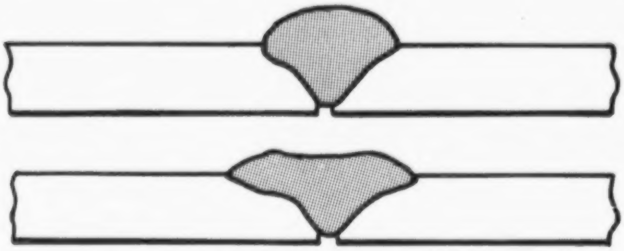
A204A-95

TM #19

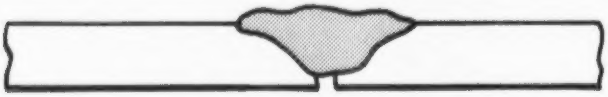
# Characteristics of Welds



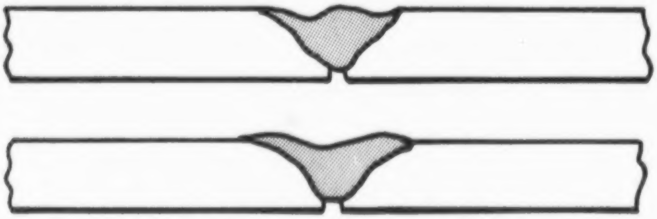
Correct Weld Contour



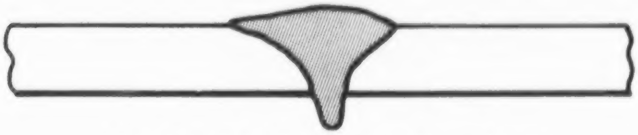
Excessive Reinforcement



Lack of Penetration



Undercutting or “Valleys”



Weld Metal Protruding

Adapted with permission of Victor Welding Company, Denton, Texas.

# Welding Tip Data

| Metal Thickness | Tip Size | Drill Size | Oxygen Pressure P.S.I.G. |  | Acetylene Pressure P.S.I.G. |  | Acetylene Consumption SCFH* |  |
|---|---|---|---|---|---|---|---|---|
|  |  |  | Min. | Max. | Min. | Max. | Min. | Max. |
| Up to 1/32" | 000 | 75 | 3 | 5 | 3 | 5 | 3/4 | 1 1/2 |
| 1/64" - 3/64" | 00 | 70 | 3 | 5 | 3 | 5 | 1 1/2 | 2 1/2 |
| 1/32" - 5/64" | 0 | 65 | 3 | 5 | 3 | 5 | 2 1/2 | 4 |
| 3/64" - 3/32" | 1 | 60 | 3 | 5 | 3 | 5 | 4 | 6 |
| 1/16" - 1/8" | 2 | 56 | 3 | 5 | 3 | 5 | 6 | 10 |
| 1/8" - 3/16" | 3 | 53 | 4 | 7 | 3 | 6 | 9 | 18 |
| 3/16" - 1/4" | 4 | 49 | 5 | 10 | 4 | 7 | 15 | 28 |
| 1/4" - 1/2" | 5 | 43 | 6 | 12 | 5 | 8 | 22 | 40 |
| 1/2" - 3/4" | 6 | 36 | 7 | 14 | 6 | 9 | 30 | 52 |
| 3/4" - 1 1/4" | 7 | 30 | 8 | 16 | 7 | 10 | 38 | 66 |
| 1 1/4" - 2" | 8 | 29 | 10 | 19 | 8 | 12 | 48 | 82 |
| 2" - 2 1/2" | 9 | 28 | 12 | 22 | 9 | 14 | 58 | 100 |
| 2 1/2" - 3" | 10 | 27 | 14 | 24 | 10 | 14 | 70 | 118 |
| 3" - 3 1/2" | 11 | 26 | 16 | 26 | 11 | 15 | 84 | 138 |
| 3 1/2" - 4" | 12 | 25 | 18 | 28 | 12 | 15 | 100 | 160 |

Gas consumption data is merely for rough estimating purposes. It will vary greatly on the material being welded and the particular skill of the operator.

Pressures are approximate for hose length up to 25 ft.

Increase for longer hose lengths about 3 psi per 25 feet.

*Oxygen consumption is 1.1 times the acetylene under neutral flame conditions.

Used with permission of Mid-America Vocational Curriculum Consortium, Stillwater, Oklahoma.

# Cutting Tip Data Chart

| Metal Thickness | Tip Size | Regulator Pressure P.S.I. | | |
|---|---|---|---|---|
| | | Acetylene | Other Fuel Gases | Oxygen |
| 1/8" | 000 | 6 | 10-11 | 23 |
| 3/16" | 00 | 6 | 10-11 | 23 |
| 1/4" | 0 | 7 | 10-11 | 33 |
| 3/8" | 0 | 7 | 10-11 | 40 |
| 1/2" | 1 | 7 | 10-11 | 40 |
| 5/8" | 1 | 7 | 10-11 | 45 |
| 3/4" | 2 | 7 | 10-11 | 40 |
| 1" | 2 | 7 | 10-11 | 45 |
| 1 1/4" | 2 | 7 | 10-11 | 55 |
| 1 1/2" | 3 | 8 | 10-11 | 50 |
| 2" | 3 | 8 | 10-11 | 55 |
| 2 1/2" | 4 | 8 | 10-11 | 45 |
| 3" | 4 | 8 | 10-11 | 50 |
| 4" | 4 | 8 | | 60 |
| 5" | 5 | 9 | | 60 |
| 6" | 5 | 9 | | 70 |
| 8" | 5 | 9 | | 80 |

Used with permission of Smith Welding Equipment Division, Tescom Corporation, Watertown, South Dakota.

A204A-101

TM #22

# Gas Welding Rod Data

| Metal | Flame Adjustment | Flux | Welding Rod |
|---|---|---|---|
| Steel, cast | Neutral | No | Steel |
| Steel pipe | Neutral | No | Steel |
| Steel plate | Neutral | No | Steel |
| Steel sheet | Neutral | No | Steel |
| | Slightly oxidizing | Yes | Bronze |
| High carbon steel | Reducing | No | Steel |
| Wrought iron | Neutral | No | Steel |
| Galvanized iron | Neutral | No | Steel |
| | Slightly oxidizing | Yes | Bronze |
| Cast iron, gray | Neutral | Yes | Cast iron |
| | Slightly oxidizing | Yes | Bronze |
| Cast iron, malleable | Slightly oxidizing | Yes | Bronze |
| Cast iron pipe, gray | Neutral | Yes | Cast iron |
| | Slightly oxidizing | Yes | Bronze |
| Cast iron pipe | Neutral | Yes | Cast iron or base metal composition |
| Chromium-nickel steel castings | Neutral | Yes | Base metal composition or 25-12 chromium-nickel steel |
| Chromium-nickel steel (18-8 and 25-12) | Neutral | Yes | Columbium stainless steel or base metal composition |
| Chromium steel | Neutral | Yes | Columbium stainless steel or base metal composition |
| Chromium iron | Neutral | Yes | Columbium stainless steel or base metal composition |

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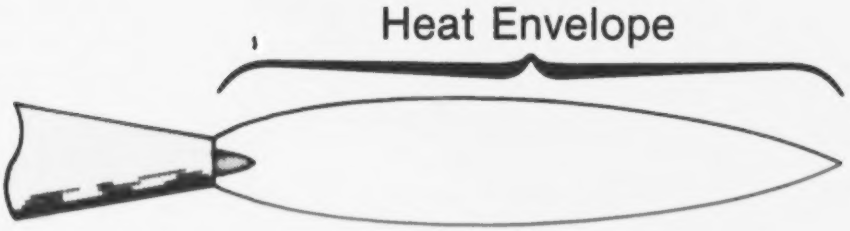
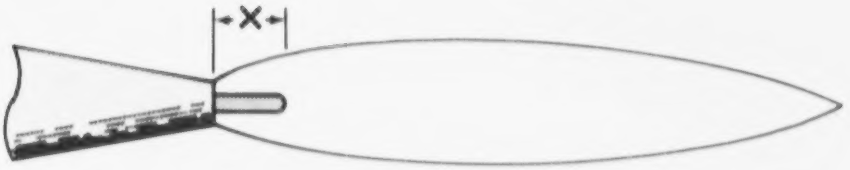
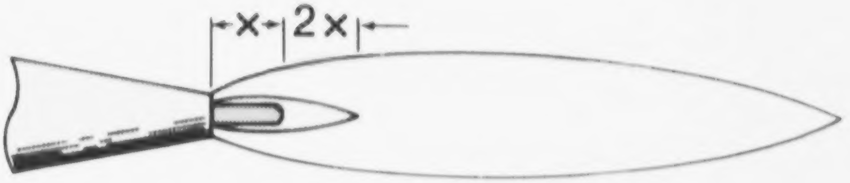
# Oxyacetylene Fusion Welding Flames



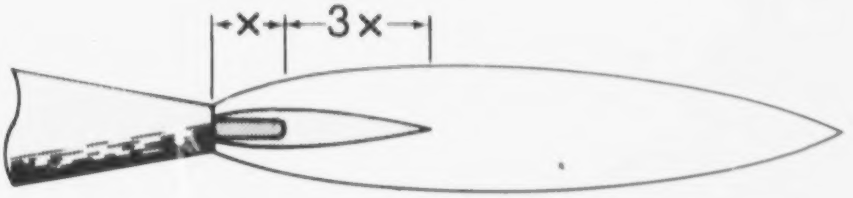
Oxidizing Flame



Neutral Flame



Reducing Flame



Carburizing Flame

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# AIRFRAME
# A204 AIRCRAFT WELDING
# PERFORM GAS WELDING AND CUTTING
# A204-A

## WORKBOOK SUPPLEMENT #1 — Interpret Safety Rules for Handling Oxygen, Acetylene, and Oxyacetylene Welding Equipment

Safety is the primary concern of the aviation maintenance technician when working in the welding area. The potential for harm to technicians and their coworkers is extremely high in a welding shop. Many of the materials are explosive, and high electrical currents pass through much of the equipment. The list of safety hazards seemingly could go on forever. The greatest responsibility for maintaining high safety standards begins with, and remains with, the individual technician. Interpret the safety rules in Technical Information Supplement #2 to answer the following questions.

A. 1. In what position should oxygen and acetylene cylinders be supported?

______________________________

2. Why?

______________________________

B. What should be done before opening the oxygen torch valve?

______________________________

C. How should cylinder valves be opened?

______________________________

D. In order to prevent damage to regulators and possible injury to the operator, what should the operator do?

______________________________

______________________________

E. When should oil or grease be used on regulators, torches or fittings?

______________________________

F. Which valve should be turned off first, the oxygen or the acetylene?

______________________________

G. When welding or cutting, always work at least ______________ feet from the cylinders.

H. List the two types of fire extinguishers that should be available when welding or cutting.

1. ______________________________

2. ______________________________

I. Can oxygen be used as a substitute for compressed air? ______________

J. In a free state, what is the highest pressure at which acetylene can be used?

______________________________

K. 1. What should be done prior to attaching the regulators to the cylinder valves?

______________________________

______________________________

2. Why?

______________________________

______________________________

L. List three items from which the hoses should be protected.

1. ______________________________

2. ______________________________

3. ______________________________

M. Explain how the operator should position himself or herself and the equipment when opening cylinder valves.

______________________________

______________________________

______________________________

N. Explain how to test connections for leaks.

______________________________

______________________________

## WORKBOOK SUPPLEMENT #1

O. List what a welder should wear when cutting or welding.

1. ______________________________________________
2. ______________________________________________
3. ______________________________________________

P. When opening an acetylene cylinder valve, the valve should never be opened more than ____________ turn(s).

Q. What should be done to protect the valves when moving or storing gas cylinders?

__________________________________________________

__________________________________________________

R. Keep hands, gloves, and clothing free from ____________ and ____________.

S. When lighting a torch you should always use a ______________________.

T. What should be done to reduce the possibility of leakage and strain on welding equipment?

__________________________________________________

__________________________________________________

U. When should oxygen and acetylene passages be purged?

__________________________________________________

(NOTE: The following statements are either true or false. Circle the correct response.)

V. A torch should always be operated in a well-ventilated area (True/False)

W. Welding close to concrete (masonry) does not create a safety hazard (True/False)

X. Never cut on or work near containers that contain or have contained combustible materials (True/False)

Y. A burning torch may be left unattended if properly secured and supported (True/False)

Z. When cutting, avoid breathing toxic fumes (True/False)

## AIRFRAME
## A204 AIRCRAFT WELDING
## PERFORM GAS WELDING AND CUTTING
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### WORKBOOK SUPPLEMENT #2 — Match Gases Used in Welding to Their Characteristics

Studying the characteristics of gases will allow the technician to develop an understanding of why gases used in oxy-fuel welding need to be handled and used in a specific manner. Also, the technician will gain the knowledge which can be useful in detecting and recognizing certain fuel gases. Match gases used in welding to their characteristics. Write the correct numbers in the blanks.

______A. This gas is made by adding water to calcium carbide crystals

______B. This gas is used for welding aluminum and magnesium because it produces a very clean flame

______C. A stable compound when it is not under pressure, but if stored under a pressure of more than about 15 psi, it becomes unstable

______D. Stored in steel cylinders under a pressure of more than 2,000 psi

______E. Does not exist free in the atmosphere; it must be manufactured

______F. If it comes in contact with oil or grease or almost any other pertroleum product, it will combine with it rapidly enough to generate sufficient heat to ignite

______G. If ignited, the result is a yellow, smoky flame with a low temperature

______H. The temperature of the flame is not as high as that produced by acetylene

______I. The most abundant substance on earth

______J. A colorless gas slightly lighter than air, with a strong and rather disagreeable odor

______K. It in itself is not combustible; unites with other materials to increase their rate of burning

______L. When it is burned in the air, it produces a white light because of the extremely large amount of carbon it contains

______M. If this is added to an acetylene flame which has a relatively low temperature, the flame will suddenly become an extremely hot flame

1. Acetylene
2. Hydrogen
3. Oxygen

Adapted with permission of International Aviation Publishers, Riverton, Wyoming.

AIRFRAME
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PERFORM GAS WELDING AND CUTTING
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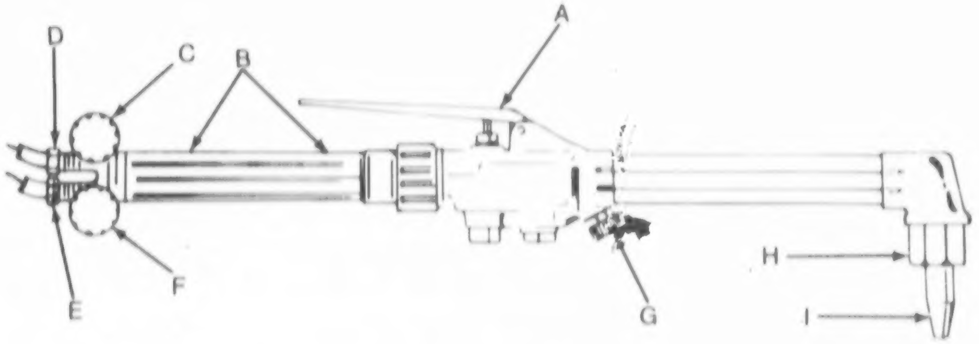
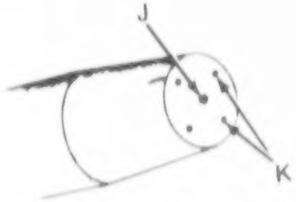
## WORKBOOK SUPPLEMENT #3 — Label Parts of a Torch Body and Cutting Attachment

Total familiarity with the cutting torch body and cutting attachment will help to increase skill and safety when using a cutting torch. Check your knowledge by completing this workbook supplement. Write the names of the parts in the blanks.





A. ____________________

B. ____________________

C. ____________________

D. ____________________

E. ____________________

F. ____________________

G. ____________________

H. ____________________

I. ____________________

J. ____________________

K. ____________________

# AIRFRAME
# A204 AIRCRAFT WELDING
# PERFORM GAS WELDING AND CUTTING
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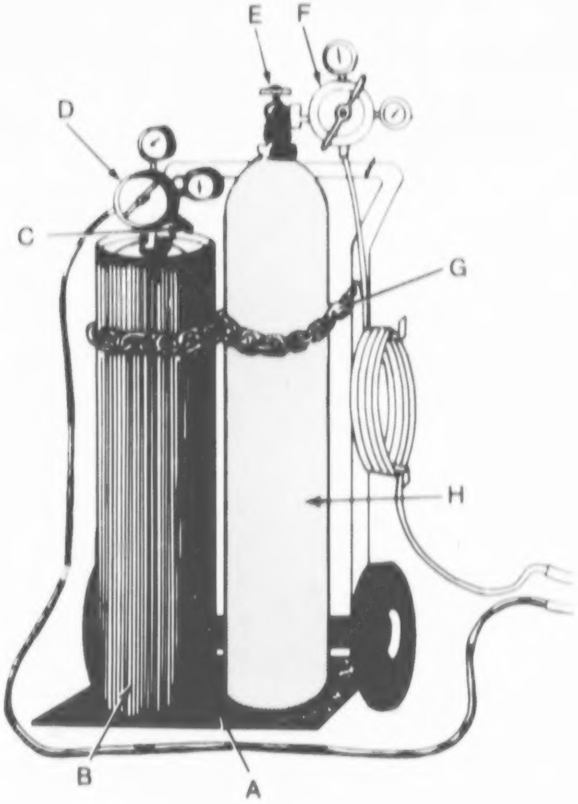
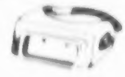
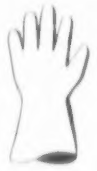
## WORKBOOK SUPPLEMENT #4 — Label Oxyacetylene Welding Equipment

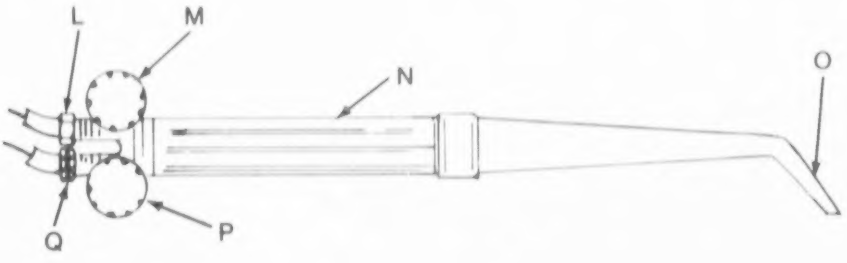
In order to weld in a safe and efficient manner, a gas welder must first become familiar with the equipment and accessories to be used. There are about seventeen items which you need to be able to identify if you are to use a portable oxyacetylene welding rig. See how many of these items you can identify by completing this workbook supplement. Write the correct names in the blanks on the next page.




I

J


K



# WORKBOOK SUPPLEMENT #4

A. ________________________________________

B. ________________________________________

C. ________________________________________

D. ________________________________________

E. ________________________________________

F. ________________________________________

G. ________________________________________

H. ________________________________________

I. ________________________________________

J. ________________________________________

K. ________________________________________

L. ________________________________________

M. ________________________________________

N. ________________________________________

O. ________________________________________

P. ________________________________________

Q. ________________________________________

# AIRFRAME
# A204 AIRCRAFT WELDING
# PERFORM GAS WELDING AND CUTTING
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## WORKBOOK SUPPLEMENT #5 — Interpret Information Related to Fusion Weld Quality

Some working procedures and skills are dedicated to the satisfactory completion of a task. Others are dedicated to preventing a disastrous accident when unusual circumstances arise. In this workbook supplement you will apply your knowledge of both.

A. Select the five factors from the following list that determine fusion weld quality. Write an "X" in the blanks before the correct answers.

_____1. Length of hose between cylinders and welder

_____2. Angle of tip

_____3. Movement of torch tip

_____4. Type of gaseous fuel being used

_____5. Speed of travel

_____6. Temperature of cylinder pressure of gaseous fuel

_____7. Distance torch tip is from work

_____8. Proper flame adjustment

B. What are the factors that determine tip size?

1. ____________________________________________

2. ____________________________________________

C. What are the factors that determine the type of filler rod to be used?

1. ____________________________________________

2. ____________________________________________

D. List in proper order the steps to follow if a flashback occurs.

1. ____________________________________________

2. ____________________________________________

3. ____________________________________________

4. ______________________________

5. ______________________________

______________________________

______________________________

______________________________

______________________________

______________________________

6. ______________________________

E. What are the causes of a backfire?

1. ______________________________

2. ______________________________

3. ______________________________

4. ______________________________

5. ______________________________

F. What are the results of a backfire and flashback?

1. Backfire

______________________________

______________________________

______________________________

______________________________

2. Flashback

______________________________

______________________________

______________________________

______________________________

## WORKBOOK SUPPLEMENT #5

G. Draw a picture for each of the four flames used in welding.

1. Oxidizing

2. Neutral

3. Reducing

4. Carburizing

# AIRFRAME
# A204 AIRCRAFT WELDING
# PERFORM GAS WELDING AND CUTTING
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## ANSWERS TO WORKBOOK SUPPLEMENTS

### Workbook Supplement #1

A. 1. Upright
    2. So they cannot be tipped over
B. Light the acetylene
C. Slowly
D. Release the pressure adjusting screw on the regulator before opening the cylinder valve
E. Never
F. Oxygen
G. Five
H. 1. Carbon dioxide
    2. Dry powder
I. No
J. 15 psi
K. 1. Cylinder valves should be blown out
    2. To remove dust and dirt that may damage the regulator
L. 1. Hot metal
    2. Rupture
    3. Mechanical damage
M. Stand to the side of the regulators, keeping the cylinder valve between the operator and regulator
N. Paint connections with Ivory soapsuds mixed with water
O. 1. Safety goggles
    2. Gloves
    3. Protective clothing
P. $\frac{1}{2}$ to $\frac{3}{4}$
Q. Steel caps should be placed on the gas cylinders
R. Oil; grease
S. Friction lighter
T. Cylinder valves should be shut off when not in use
U. Before lighting the torch
V. True
W. False
X. True
Y. False
Z. True

# ANSWERS TO WORKBOOK SUPPLEMENTS

## Workbook Supplement #2

A. 1
B. 2
C. 1
D. 3
E. 1
F. 3
G. 1
H. 2
I. 3
J. 1
K. 3
L. 1
M. 3

## Workbook Supplement #3

A. Oxygen cutting lever
B. Torch body
C. Oxygen torch valve
D. Oxygen fitting (right-hand threads)
E. Acetylene fitting (hex-grooved nut, left-hand threads)
F. Acetylene torch valve
G. Oxygen preheat valve
H. Tip nut
I. Slip-in tip
J. Cutting orifice
K. Preheat orifices

## Workbook Supplement #4

A. Cylinder truck
B. Acetylene cylinder
C. Acetylene cylinder valve
D. Acetylene regulator
E. Oxygen cylinder valve
F. Oxygen regulator
G. Safety chain
H. Oxygen cylinder
I. Welding goggles
J. Flint lighter
K. Welding gloves
L. Oxygen fitting (right-hand threads)
M. Oxygen torch valve
N. Torch body
O. Welding tip
P. Acetylene torch valve
Q. Acetylene fitting (hex-grooved nut, left-hand threads)

## ANSWERS TO WORKBOOK SUPPLEMENTS

Workbook Supplement #5

A. 2, 3, 5, 7, 8

B. 1. Metal thickness
   2. Size of welding rod

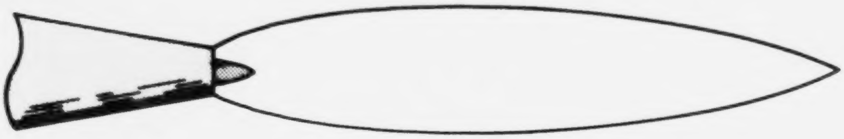
C. 1. Rod with similar properties as base metal
   2. Thickness of metal

D. 1. Do not panic
   2. Close oxygen preheat valve
   3. Close oxygen torch valve
   4. Close acetylene torch valve
   5. Shut off oxygen cylinder valve first and then the acetylene cylinder valve, unless you see the hose flame heading right for the acetylene cylinder; if it is, you will have to quickly decide either to turn off the cylinder valve or to run
   6. Disassemble, inspect, and replace any damaged equipment before relighting

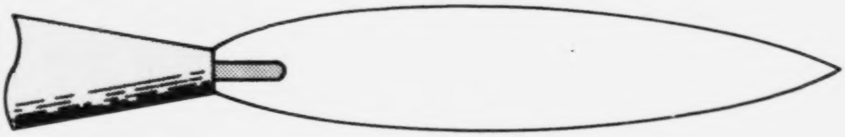
E. 1. Insufficient acetylene or oxygen pressure
   2. Loose torch tip
   3. Dirty tip
   4. Overheating of cutting tip
   5. Bad O-ring in torch body

F. 1. Flame burns momentarily back into tip; a loud snap or pop results; flame may go out; flame may continue to burn in normal manner
   2. Fire inside torch; disappearance of flame followed by squealing or hissing noise inside torch, sparks coming from the torch, smoke coming from the torch

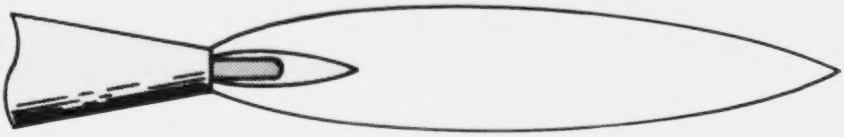
G. 1. Oxidizing



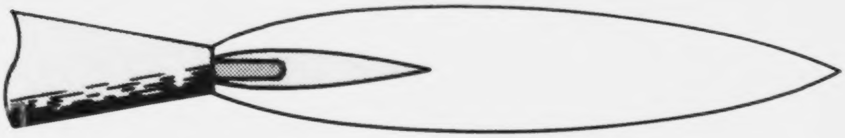
   2. Neutral



3. Reducing



4. Carburizing



# AIRFRAME
## A204 AIRCRAFT WELDING
## PERFORM GAS WELDING AND CUTTING
## A204-A

### PROJECT GUIDE #1 — Set Up Equipment for Oxyacetylene Cutting

PURPOSE: To allow you to develop skill in setting up equipment used to cut mild steel using oxyacetylene gas processes.

REFERENCE MANUALS:

A. EA-ITP-AB

B. AC 65-15A

EQUIPMENT AND TOOLS:

A. Oxygen cylinder

B. Acetylene cylinder

C. Oxygen regulator

D. Acetylene regulator

E. Hoses

F. Universal cylinder wrench

G. Cylinder holder

H. Water container

I. Clean paintbrush

J. Torch body with tips

K. Oxygen and acetylene check valves

L. Protective clothing

M. Safety glasses

N. Gloves

SUPPLIES AND MATERIALS:

A. Castile soap (Ivory)

B. Clean, lint-free cloth

## PROJECT GUIDE #1

PROCEDURE:

PART I — Equipment set-up

A. Put on protective clothing, safety glasses, and gloves

(NOTE: Put on safety glasses immediately. Most shops require workers to wear them at all times. Put gloves on now. Learn to work with your gloves on at all times while in the welding area.)

B. Check work area to make sure if free of flammable materials and is well ventilated, and note nearest location of fire extinguisher

C. Set up welding screen, curtain, or sheet metal deflector around work area

(NOTE: Skip this step if you are in a welding booth.)

D. Chain cylinders in vertical position to wall, post, or cylinder cart

E. Remove safety caps from cylinders

(NOTE: Keep safety caps close by so they are not lost.)

F. Crack each cylinder valve, then close

(NOTE: This step clears dirt from inside cylinder valves.)

**WARNING**

**Stand to the side of each cylinder valve when completing this step.**

G. Clean outlets of cylinder valves with cloth

H. Open regulators by turning regulator-adjustment handles in (clockwise) until moderate resistance is felt

(NOTE: This is done to release any gases which may be trapped in the regulators.)

**CAUTION**

Do not overtighten adjustment handles.

I. Close both oxygen and acetylene regulators by turning regulator-adjustment handles out (counterclockwise) until they turn freely

J. Attach oxygen and acetylene regulators to cylinders, making connections finger tight

(NOTE: Do not force connections.)

**WARNING**

**Ensure fuel-gas regulator is correct for acetylene gas.**

K. Tighten regulator connecting nuts with wrench

(NOTE: A universal cylinder wrench is the most preferred tool for tightening these nuts.)

**CAUTION**

Do not overtighten connections.

L. Recheck oxygen and acetylene regulators to ensure that they are in closed position

M. Very slowly crack oxygen cylinder valve a small amount, and allow cylinder pressure to build up in high-pressure chamber of regulator

(NOTE: Observe pressure build-up on cylinder-pressure gauge. There should not be any reading on the working-pressure gauge of regulator. If there is a reading, close cylinder valve immediately and close regulator by turning regulator adjustment handle counterclockwise.)

**WARNING**

**Never stand in front or back of regulator when opening cylinder valve! Stand well to the side of the regulator.**

N. Slowly open oxygen cylinder valve to its full, open position

(NOTE: Make sure there is enough gas pressure for the job. Now is the time to change bottles if your bottle is nearly empty.)

O. Slowly crack the acetylene cylinder valve a very small amount, and allow pressure to build up in high-pressure chamber of regulator

(NOTE: Observe pressure build-up on cylinder-pressure gauge. There should not be any reading on the working-pressure gauge of regulator. If there is a reading, close cylinder valve immediately and close regulator by turning regulator adjustment handle counterclockwise.)

**WARNING**

**Never stand in front or back of regulator when opening cylinder valve! Stand well to the side of the regulator.**

P. Open acetylene cylinder valve one-half to three-quarters of a turn, and leave wrench on valve

(NOTE: Never open acetylene cylinder valve more than three-quarters of a turn.)

**WARNING**

**When a universal cylinder wrench is used to open an acetylene cylinder, it should be left in place during all operations to permit rapid shutdown in case of emergency.**

Q. Check all connections with thick solution of castile soap and water

> **WARNING**
>
> **Do not use soap derived from animal fat as this may result in a fire or an explosion.**

(NOTE: Small leaks may be corrected by slight, additional tightening of connections.)

R. Inspect hoses

(NOTE: Cuts and worn spots are the most common defects in used hose.)

S. Attach green hose to oxygen regulator and red hose to acetylene regulator

(NOTE: The acetylene fitting has a left-handed, notched connecting nut. The oxygen fitting has a right-handed connecting nut.)

T. Clean safety check valves and torch inlets with cloth

U. Attach safety check valves to torch finger tight

V. Attach hoses to check valves finger tight

(NOTE: Ensure the correct valve is used on the correct torch inlet. Check valves are marked for oxygen or fuel-gas.)

W. Tighten all connections near torch inlets with wrench

> **CAUTION**
>
> Do not overtighten.

X. Close fuel and oxygen torch valves with fingers

> **CAUTION**
>
> Never use a tool on these valves.

(NOTE: There are two valves on the torch which regulate oxygen: the torch valve and the preheat valve. Close both of these valves.)

Y. Turn adjusting screw clockwise on oxygen and acetylene regulators until recommended delivery pressures are reached on working-pressure gauges

Z. Check connections for leaks by turning pressure regulator adjustment handles in, with torch needle valves closed; when 20 psi shows on the oxygen working-pressure gauge and 5 psi on the acetylene gauge, close valves by turning pressure regulator adjustment handles out

(NOTE: A drop in pressure on the working-pressure [delivery] gauge indicates a leak between the regulator and torch tip. A general tightening of all connections should remedy the situation. If it becomes necessary to locate a leak, use the soapsuds method. Do this by painting all fittings and connections with a thick solution of soapy water.)

**WARNING**

**Never check for acetylene leaks with a flame since a serious explosion could occur in the hose or in the cylinder.**

PART II — Equipment disassembly

A. Close oxygen and acetylene cylinder valves

B. Open acetylene valve on torch to bleed line, torch, and regulator

**WARNING**

**This step is safe only in a well-ventilated area. Do not point the torch at anyone or anything which could burn.**

(NOTE: The high- and low-pressure gauges should now read zero. If they do not read zero, repeat Steps A and B.)

C. Close acetylene torch valve

**WARNING**

**This will ensure the oxygen will not backflow into acetylene line.**

D. Open oxygen torch valve and preheat valve to bleed line, torch, and regulator

**WARNING**

**Do not point the torch at anyone or anything which could burn.**

(NOTE: The cylinder- and working-pressure gauges should now read zero. If the gauges do not read zero, repeat Steps A and D.)

E. Close oxygen torch valve and preheat valve

F. Close acetylene and oxygen regulators by turning regulator adjustment handles counterclockwise until they turn freely

G. Disconnect torch, hoses, and regulators

H. Replace safety caps on bottles

I. Check in tools and equipment, or prepare for next project as directed by instructor

AIRFRAME
A204 AIRCRAFT WELDING
PERFORM GAS WELDING AND CUTTING
A204-A

## PROJECT GUIDE #2 — Turn On, Light, and Adjust Cutting Torch To Neutral Flame, and Turn Off Oxyacetylene Cutting Equipment

PURPOSE: To allow you to develop skill in lighting the torch, adjusting the torch's flame, and turning off the equipment properly to ensure a safe work environment.

REFERENCE MANUALS:

A. EA-ITP-AB

B. AC 65-15A

EQUIPMENT AND TOOLS:

A. Oxygen cylinder

B. Acetylene cylinder

C. Oxygen and acetylene regulators

D. Hoses

E. Torch body

F. Cutting attachment with slip-in tip

G. Cylinder holder and hose rack

H. Flint lighter

I. Wrench

J. Gloves

K. Safety glasses

L. Welding goggles

M. Coveralls or protective clothing

PROCEDURE:

A. Check all cylinder, regulator, and torch valves to make sure they are closed

B. Inspect and remove from work area any materials which are combustible and unnecessary to cutting process, and note nearest location of fire extinguisher

> **WARNING**
>
> **Be sure any necessary materials which are combustible are located a sufficient distance away when equipment is purged or when the torch is burning.**

C. Put on protective clothing, safety glasses, and gloves

D. Open acetylene cylinder valve one-half to three-quarters of a turn

> **WARNING**
>
> **Never open acetylene cylinder valve more than three-quarters of a turn.**

E. Open acetylene torch valve one turn

F. Turn adjustment handle on acetylene regulator clockwise until desired pressure is reached; allow acetylene to flow 5 to 10 seconds for each 50 feet of hose being used

(NOTE: Oxygen and acetylene delivery pressures and size of tip depend upon the thickness of metal to be cut. Use pressures and tip size recommended by manufacturer. Delivery pressures are indicated on the working-pressure gauge.)

> **WARNING**
>
> **Never point your torch at anyone or anything that will burn.**

G. Close acetylene valve on torch

H. Open oxygen cylinder valve all the way

I. Open oxygen torch valve all the way

J. Open oxygen preheat valve on cutting attachment one turn

K. Turn adjustment handle on oxygen regulator clockwise until desired pressure is reached; allow oxygen to flow 5 to 10 seconds for each 50 feet of hose used

> **WARNING**
>
> **Never point torch at anyone or anything that will burn.**

L. Close oxygen preheat valve on cutting attachment

M. Put on welding or cutting goggles

N. Open acetylene valve on torch one-quarter of a turn

O. Light torch with flint lighter, and adjust acetylene valve until smoke or flame clears

P. Slowly open oxygen preheat valve, and adjust to a neutral flame

Q. Depress oxygen cutting lever and check to see that neutral flame is present

(NOTE: If necessary, adjust the oxygen preheat valve with the oxygen cutting lever depressed until a neutral flame is secured.)

R. Close torch valves in sequence recommended by manufacturer

**WARNING**

**If the fuel valve is turned off first, a "pop" may occur. The "pop" causes carbon soot to be thrown back into the torch and may eventually cause clogging of the gas passages. Another thing which may occur is that the operator might believe that the gas is fully off when the flame goes out; this may not be true. The flame will go out from an overly lean condition before the the valve is fully closed. If the acetylene valve is left partially open, the conditions for an explosion could result.**

(NOTE: You may now remove protective welding goggles, and wear safety glasses.)

S. Close acetylene cylinder valve

T. Close oxygen cylinder valve

U. Open acetylene torch valve

**WARNING**

**This step is safe only in a well-ventilated area.**

V. Open oxygen torch preheat valve; when gauges reach zero, close oxygen preheat valve and release adjusting screw on oxygen regulator by turning counterclockwise

W. Close oxygen torch valve

X. Place torch and hose on hanger or brackets provided

Y. Have instructor check for proper shutdown

Z. Check in tools and equipment, or prepare for next project as directed by instructor

# AIRFRAME
# A204 AIRCRAFT WELDING
# PERFORM GAS WELDING AND CUTTING
# A204-A

## PROJECT GUIDE #3 — Cut Mild Steel Flat Plate

PURPOSE: To allow you to develop skill in using oxyacetylene cutting equipment to cut mild steel.

REFERENCE MANUAL: *Welding, Cutting, and Heating Guide*

EQUIPMENT AND TOOLS:

A. Cutting outfit with tip assembly

B. Straightedge

C. Gloves

D. Welding goggles

E. Pliers

F. Protective clothing

G. Flint lighter

H. Welding or cutting table

I. Slag box

J. Can of water

K. Cutting tip

SUPPLIES AND MATERIALS:

A. 4" or wider × 8" or longer mild steel plate, ¼ inch to ½ inch thick

B. Soapstone with sharp point or edge

PROCEDURE:

A. Check area to make sure it is free of flammable materials and is well ventilated, and note nearest location of fire extinguisher

B. Mark four parallel lines 2 inches apart on plate to be cut

C. Determine regulator pressures required; set up and purge regulators

D. Place plate to be cut over slag box

E. Put on gloves and welding goggles

F. Light torch

G. Adjust to neutral flame

H. Assume comfortable position

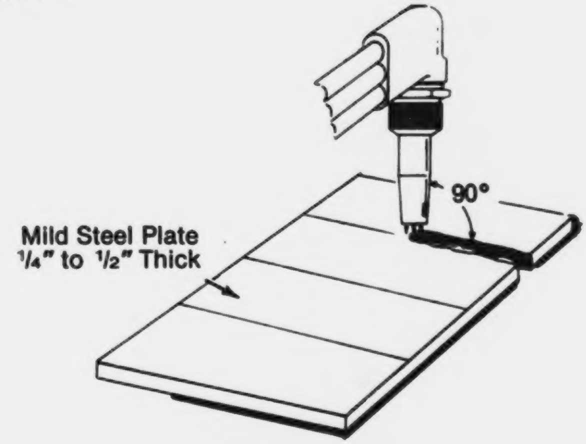
I. Place hoses behind operator

J. Maneuver torch with both hands

K. Hold preheat flame with tip of inner cone 1/16 inch to 1/8 inch above top of plate at right edge until red spot appears

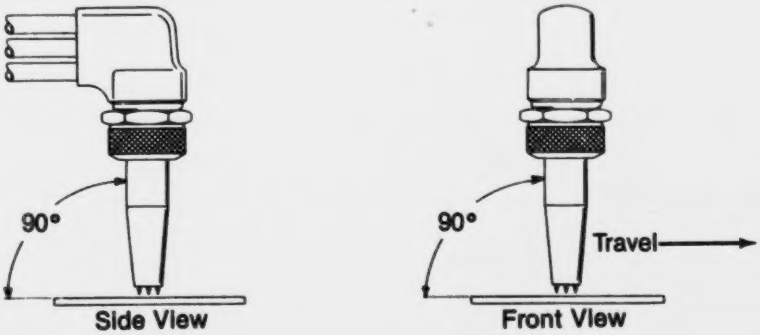
L. Depress the oxygen cutting lever, and move from right to left across plate (for left-handed operators, go from left to right) (Figure 4)

FIGURE 4


90°
Mild Steel Plate
1/4" to 1/2" Thick

M. Hold tip at right angles to work while cutting with inner cone being 1/16 inch to 1/8 inch above work (Figure 5)

FIGURE 5


90°
Side View
90°
Travel
Front View

## PROJECT GUIDE #3

N. Make 90-degree cuts until you have developed the proper procedure

O. Release the oxygen cutting lever

P. Shut down torch

Q. Cool metal by placing in can of water with the aid of pliers

R. Show samples to instructor for evaluation

S. Relight torch and adjust to neutral flame

T. Preheat edge (only) of metal where cutting action was stopped

U. Slowly depress oxygen cutting lever and continue cut

V. Finish cut and shut down equipment

W. Have instructor check and evaluate your work

X. Check in tools and equipment, or prepare for next project as directed by instructor

Project Guide #3 adapted with permission of Mid-America Vocational Curriculum Consortium, Stillwater, Oklahoma.

# AIRFRAME
# A204 AIRCRAFT WELDING
# PERFORM GAS WELDING AND CUTTING
# A204-A

## PROJECT GUIDE #4 — Turn On, Light, Adjust, and Turn Off Oxyacetylene Welding Equipment

PURPOSE: To allow you to develop skill in lighting and adjusting oxyacetylene torch to neutral flame. You will also gain skill in properly shutting down equipment.

REFERENCE MANUALS:

A. EA-ITP-AB

B. AC 65-15A

C. *Welding, Cutting, and Heating Guide*

EQUIPMENT AND TOOLS:

A. Oxyacetylene cylinders and torch assembly

B. Spark lighter

C. Protective clothing

D. Welding goggles

E. Welding gloves

PROCEDURE:

**WARNING**

**Do not carry a cigarette lighter filled with propane or butane while doing this procedure.**

A. Check area to make sure it is free of flammable materials and is well ventilated, and note nearest location of fire extinguisher

B. Put on protective clothing, welding goggles, and welding gloves

C. Inspect torch valves to make sure they are both turned off, then slightly open each valve adjustment screw

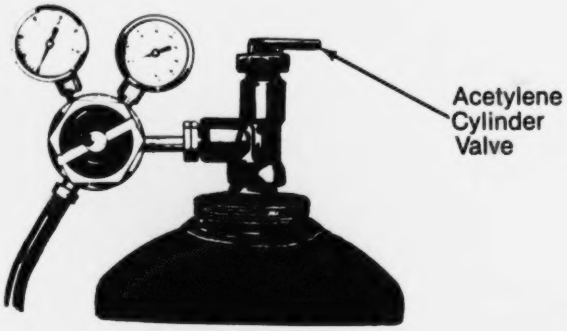
(NOTE: Opening the adjustment screws slowly all the way helps to prevent rupture of the regulator when the cylinder valve is opened.)

D. Open acetylene cylinder valve slowly about half a turn (See Figure 6)

**WARNING**

**Never open an acetylene regulator valve above 15 psi because pressure beyond that point could literally cause the regulator to explode.**

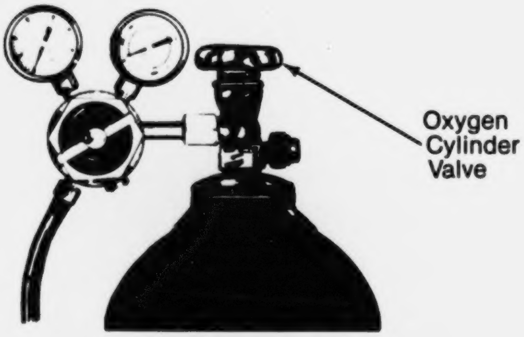
FIGURE 6



E. Tighten adjustment screw on acetylene regulator by slowly turning it to the right until acetylene working-pressure gauge indicates 5 pounds of pressure or to recommended pressure

F. Open valve on oxygen cylinder by slowly turning it to the left as far as it will go (Figure 7)

FIGURE 7



G. Tighten adjustment screw on oxygen regulator by turning it to the right until oxygen working-pressure gauge indicates 10 pounds of pressure

H. Take torch in your right hand, and point tip down and away from you into a clear, safe area

I. Purge both lines

(NOTE: The purging procedure gets impurities out of the lines and assures a steady flow of gases for lighting the torch. Purging normally requires 5 to 10 seconds for every 50 feet of hose being used.)

PROJECT GUIDE #4

**WARNING**

**To avoid a dangerous build-up of acetylene, only one student at a time should perform this procedure, and the area should be free of acetylene before another student attempts the purging procedure.**

1. Crack acetylene torch valve with your left hand until you hear acetylene escaping from end of tip

   (NOTE: At first the acetylene will make an irregular hissing sound then a low, steady hissing sound that indicates the acetylene line is purged.)

2. Look at acetylene working-pressure gauge to make sure it remains at 5 pounds of pressure

3. Slowly turn off acetylene torch valve

   (NOTE: Develop the habit of opening and closing torch valves with care. Forcing them quickly can damage them.)

4. Repeat procedure with oxygen line, and make sure oxygen working-pressure gauge remains at 10 pounds of pressure

J. Keep torch tip pointed down and away from you as you take spark lighter in your other hand

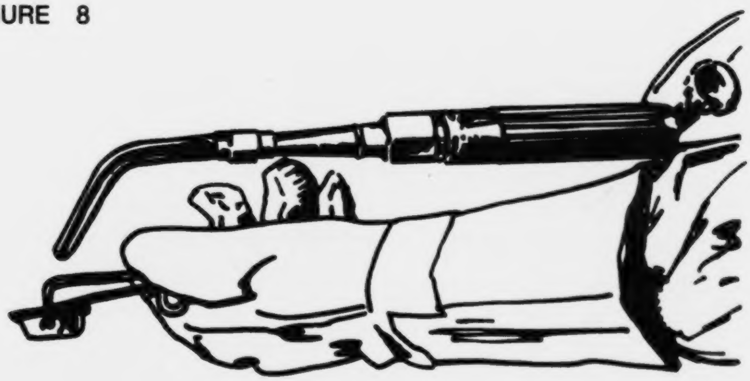
K. Open acetylene torch valve about a quarter turn

L. Keep torch pointed down and away from you

(NOTE: Acetylene produces a black smoke when it burns, so make the following adjustments as quickly as possible.)

M. Place spark lighter about 1 inch below torch tip, and squeeze it quickly and firmly to make it spark and light acetylene (Figure 8)

FIGURE 8



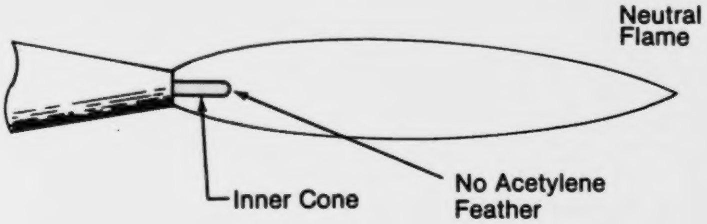
N. Open acetylene torch valve until flame is about 3/4 inch away from tip of torch, a blue flame appears, and carbon smoke diminishes

O. Slowly open oxygen torch valve to allow oxygen to mix with acetylene

P. Continue opening torch valve until mixture and pressure create sharp, inner cone of fire at torch tip (Figure 9)

(NOTE: Proper adjustment creates a neutral flame and indicates a correct mixture of oxygen and acetylene.)

FIGURE 9



Q. Continue moving oxygen torch valve slowly to different positions to purposely create improper flames, then readjust to neutral flame

(NOTE: This exercise should help you to quickly recognize a neutral flame and the adjustments required to create and maintain a neutral flame.)

R. Have instructor check your flame and pressure settings

S. Prepare to shut down equipment

T. Close oxygen torch valve

U. Close acetylene torch valve

V. Close oxygen cylinder valve

W. Close acetylene cylinder valve

X. Open acetylene torch valve to bleed acetylene line

Y. Allow acetylene working-pressure gauge to return to zero, then loosen acetylene regulator adjustment screw, and close acetylene adjustment screw on torch

**CAUTION**

Ensure acetylene valve on the torch is closed.

# PROJECT GUIDE #4

Z. Repeat Steps X and Y for oxygen line

AA. Place hoses and torch on welding rack and secure all equipment

BB. Have instructor check for proper shutdown

CC. Check in tools and equipment, or prepare for next project as directed by instructor

Project Guide #4 adapted with permission of Mid-America Vocational Curriculum Consortium, Stillwater, Oklahoma.

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# A204 AIRCRAFT WELDING
# PERFORM GAS WELDING AND CUTTING
# A204-A

## PROJECT GUIDE #5 — Lay Beads on Mild Steel Plate Without Filler Rod

PURPOSE: To allow you to develop skill in creating a bead on flat metal without introducing any filler. You will also gain skill in holding and moving the torch properly.

REFERENCE MANUALS:

A. EA-ITP-AB

B. AC 65-15A

C. *Welding, Cutting, and Heating Guide*

EQUIPMENT AND TOOLS:

A. Oxyacetylene welding unit

B. Protective clothing

C. Welding gloves

D. Welding goggles

E. Pliers

F. Spark lighter

SUPPLIES AND MATERIALS: Mild steel plate as selected by instructor

PROCEDURE:

A. Check work area to make sure it is free of flammable materials and is well ventilated, and note nearest location of fire extinguisher

B. Secure workpiece

C. Check thickness of workpiece, select proper tip, and place and tighten tip onto welding torch finger tight

D. Determine regulator pressures required; set up and purge regulators and lines

E. Put on welding gloves and welding goggles

F. Light torch and adjust to a neutral flame following procedures in Project Guide #4

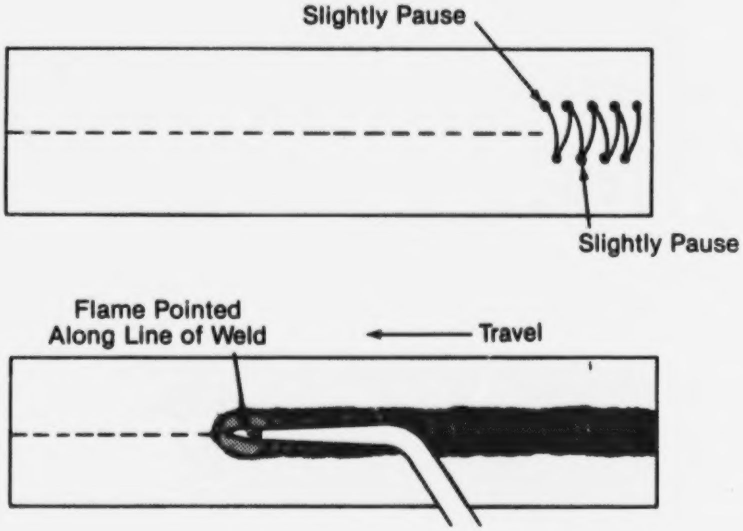
G. Hold torch comfortably with either hand and use forehand welding technique

(NOTE: For a right-handed welder, the forehand technique travels from right to left, and for a left-handed welder, the forehand technique travels from left to right.)

H. Move torch down until inner cone of flame is about 1/8 inch from surface of metal, and hold it there until a small pool of molten metal forms

I. Move flame back and forth in a series of short arcs or semicircles while you advance puddle as steadily as possible across plate (Figure 10)

FIGURE 10



J. Keep puddle oval-shaped and bead as straight as possible as you continue forming bead

(NOTE: A thin puddle or bead indicates welding speed is too fast, and a large, round puddle that tends to spark indicates welding speed is too slow or the tip is too close to the workpiece.)

K. Begin compensating for heat build-up after you have finished first two-thirds of weld by increasing welding speed slightly and as weld puddle indicates

L. Stop before reaching end of weld so molten metal will not drip off edge of plate

M. Leave about 1/2 inch between welds, and start a second weld just below beginning point of first weld

N. Increase welding speed slightly as you finish second weld to compensate for heat build-up in plate

O. Finish second weld and continue making more welds ½ inch apart and parallel with first two welds

P. Observe puddle shape in relation to torch movement at all times, and practice making slight adjustments required in welding speed

(NOTE: Most beginners are uptight at this point and have white knuckles under their gloves, and that is a good time to relax and concentrate completely on the manipulation of the torch and the formation of a well-shaped puddle.)

Q. Complete final weld, and shut off torch and shut down equipment

R. Have instructor check and evaluate your work and check for proper shutdown

S. Cool and place all welded scrap material in a proper container and clean area as required

(NOTE: Develop the habit of conserving materials and saving all scraps that can be used.)

T. Check in tools and equipment, or prepare for next project as directed by instructor

Project Guide #5 adapted with permission of Mid-America Vocational Curriculum Consortium, Stillwater, Oklahoma.

# AIRFRAME
# A204 AIRCRAFT WELDING
# PERFORM GAS WELDING AND CUTTING
# A204-A

## PROJECT GUIDE #6 — Lay Beads on Mild Steel Plate With Filler Rod

PURPOSE: To allow you to develop skill in creating a bead on flat metal through the use of filler rod and proper control of the torch.

REFERENCE MANUALS:

A. EA-ITP-AB

B. AC 65-15A

C. *Welding, Cutting and Heating Guide*

EQUIPMENT AND TOOLS:

A. Oxyacetylene welding unit

B. Protective clothing

C. Welding gloves

D. Welding goggles

E. Pliers

F. Spark lighter

SUPPLIES AND MATERIALS:

A. Mild steel plate as selected by instructor

B. Mild steel welding rod as selected by instructor

PROCEDURE:

A. Check work area to make sure it is free of flammable materials and is well ventilated, and note nearest location of fire extinguisher

B. Secure workpiece

C. Check thickness of workpiece, select proper tip, and place and tighten tip onto welding torch finger tight

D. Determine regulator pressures required; set up and purge regulators and lines

E. Put on welding gloves and welding goggles

F. Light torch and adjust to neutral flame

G. Place filler rod so that it is half off the work table, hold free end of rod, then heat rod at midway point until it melts in two

(NOTE: Doing this makes a shorter rod which is easier for a beginner to manipulate and helps eliminate the possibility of someone walking by and hitting the back end of a longer rod and interfering with the welding or maybe injuring an eye.)

H. Hold torch comfortably with one hand and filler rod with other hand, and use forehand welding technique

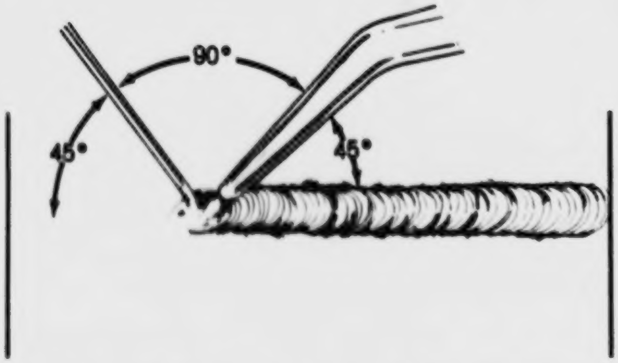
I. Move torch down until inner cone of flame is about 1/8 inch from surface of metal, and hold it there until a small pool of molten metal forms, then begin a slight circular motion with torch

J. Move rod into center of puddle at point of inner cone and let a drop or two of molten metal fill puddle

K. Withdraw rod about 1/2 inch to 3/4 inch from inner cone so that torch can be moved forward

L. Advance puddle forward with a slight circular motion of torch, and reinsert rod into center of puddle at point of inner cone and let a drop or two of molten metal fill puddle (Figure 11)

FIGURE 11



M. Withdraw rod, advance torch in a circular motion so that a continuous oval-shaped puddle is formed, then reinsert rod as before and continue procedure until first weld is completed

N. Stop before reaching end of plate so molten metal will not drip off edge of plate

## PROJECT GUIDE #6

O. Move a short distance down plate, run another bead parallel to first weld, and continue laying parallel beads as plate space will permit

(NOTE: Your instructor may direct you to change hands at any point in this activity to give you the feel of working the rod and torch in different hands and to help improve your manipulative skills.)

P. Turn off torch and shut down equipment

Q. Have instructor check and evaluate your work and check for proper shutdown

R. Cool and place all welded scrap material in a proper container, and clean area as required

S. Check in tools and equipment, or prepare for next project as directed by instructor

Project Guide #6 adapted with permission of Mid-America Vocational Curriculum Consortium, Stillwater, Oklahoma.

# AIRFRAME
# A204 AIRCRAFT WELDING
# PERFORM GAS WELDING AND CUTTING
# A204-A

## PROJECT GUIDE #7 — Weld a Butt Joint in Flat Position Using Mild Steel

PURPOSE: To allow you to develop skill in joining mild steel using the butt-joint method and oxyacetylene welding equipment. You will gain experience in selecting torch tips and filler rods, adjusting equipment, and handling the torch and filler rod.

REFERENCE MANUALS:

A. EA-ITP-AB

B. AC 65-15A

C. *Welding, Cutting, and Heating Guide*

EQUIPMENT AND TOOLS:

A. Oxyacetylene welding unit

B. Protective clothing

C. Welding gloves

D. Welding goggles

E. Pliers

F. Spark lighter

SUPPLIES AND MATERIALS:

A. Mild steel plates as selected by instructor

B. Mild steel welding rod as selected by instructor

PROCEDURE:

A. Check work area to make sure it is free of flammable materials and is well ventilated, and note nearest location of fire extinguisher

B. Check thicknesses of workpieces, select proper tip, and place and tighten tip onto welding torch finger tight

C. Determine regulator pressures required; set up and purge regulators and lines

D. Check joint to make sure it is properly prepared and properly fitted

E. Put on welding gloves and welding goggles

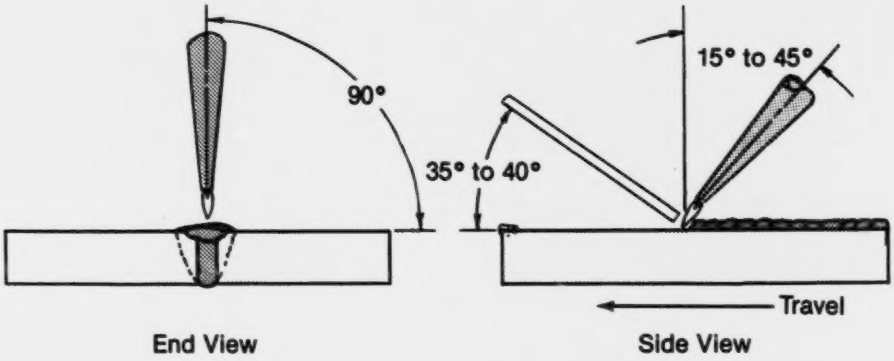
F. Light torch and adjust to neutral flame

G. Hold torch comfortably with one hand and filler rod with other hand, and use forehand welding technique

H. Tack weld joint at each end

I. Position torch and rod so that torch flame points toward unfinished end of weld and rod points toward finished end of weld (Figure 12)

FIGURE 12



J. Move torch down until inner cone of flame is about 1/8 inch from surface of metal, and hold it there until a small pool of molten metal forms, then begin a slight circular movement with torch

K. Move rod into center of puddle at point of inner cone and let a drop or two of molten metal fill puddle as you move rod in a slight circular motion

L. Withdraw rod about 1/2 inch to 3/4 inch from inner cone so that torch can be moved forward

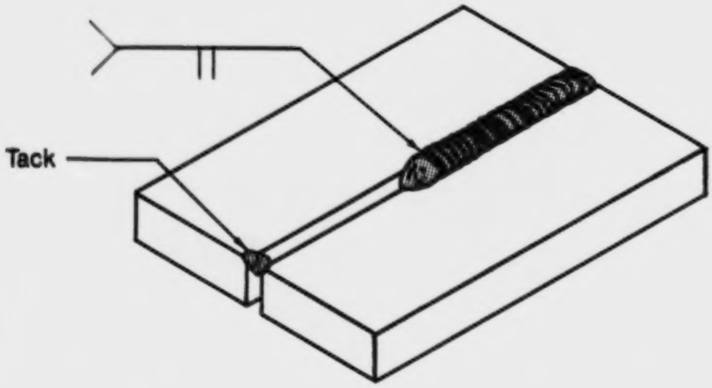
M. Advance puddle forward with a slight circular motion of torch, and reinsert rod into center of puddle at point of inner cone and let a drop or two of molten metal fill puddle as you move rod in a circular motion

N. Withdraw rod, advance torch in a circular motion so that a continuous oval-shaped puddle is formed, then reinsert rod as before and continue technique until weld is completed (See Figure 13)

(NOTE: In the following illustration, the AWS welding symbol for this joint has been added so you can become used to associating welding symbols with the welds they represent.)

## PROJECT GUIDE #7

FIGURE 13



O. Stop before reaching end of joint so molten metal will not drip off edge

P. Turn off torch and shut down equipment

Q. Have instructor check and evaluate your work and check for proper shutdown

R. Cool and place all welded scrap material in a proper container, and clean area as required

S. Check in tools and equipment, or prepare for next project as directed by instructor

Project Guide #7 adapted with permission of Mid-America Vocational Curriculum Consortium, Stillwater, Oklahoma.

## AIRFRAME
## A204 AIRCRAFT WELDING
## PERFORM GAS WELDING AND CUTTING
## A204-A

### PROJECT GUIDE #8 — Weld a Lap Joint in Flat Position Using Mild Steel

PURPOSE: To allow you to gain experience joining metals using the lap-joint method. You will also gain skill in handling the torch, selecting rods, selecting torch tips, and adjusting equipment to perform this type of welding procedure.

REFERENCE MANUALS:

A. EA-ITP-AB

B. AC 65-15A

C. *Welding, Cutting, and Heating Guide*

EQUIPMENT AND TOOLS:

A. Oxyacetylene welding unit

B. Protective clothing

C. Welding gloves

D. Welding goggles

E. Pliers

F. Spark lighter

G. Small C-clamp

SUPPLIES AND MATERIALS:

A. Mild steel plates as selected by instructor

B. Mild steel welding rod as selected by instructor

PROCEDURE:

A. Check work area to make sure it is free of flammable materials and is well ventilated, and note nearest location of fire extinguisher

B. Check thicknesses of workpieces, select proper tip, and place and tighten tip onto welding torch finger tight

C. Determine regulator pressures required; set up and purge regulators and lines

D. Check joint to make sure it is properly prepared and properly fitted

E. Put on welding gloves and welding goggles

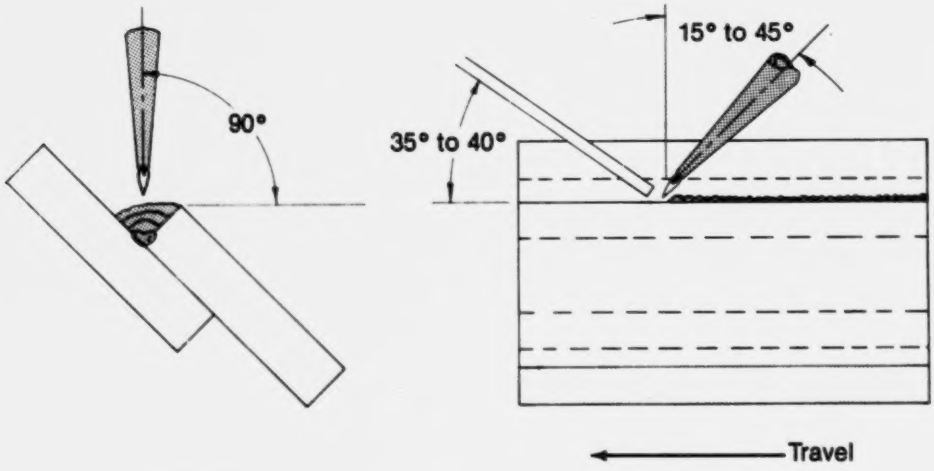
F. Light torch and adjust to neutral flame

G. Hold torch comfortably with one hand and filler rod with other hand, and use forehand welding technique

H. Tack weld joint at each end

I. Position torch and rod so that torch flame points toward unfinished end of weld and rod points toward finished end of weld (Figure 14)

FIGURE 14



End View

Side View

J. Move torch down until inner cone of flame is about 1/8 inch from surface of metal, and hold it there until a small pool of molten metal forms, then begin a slight circular movement with torch

K. Move rod into center of puddle at point of inner cone and let a drop or two of molten metal fill puddle as you move rod in a slight circular motion

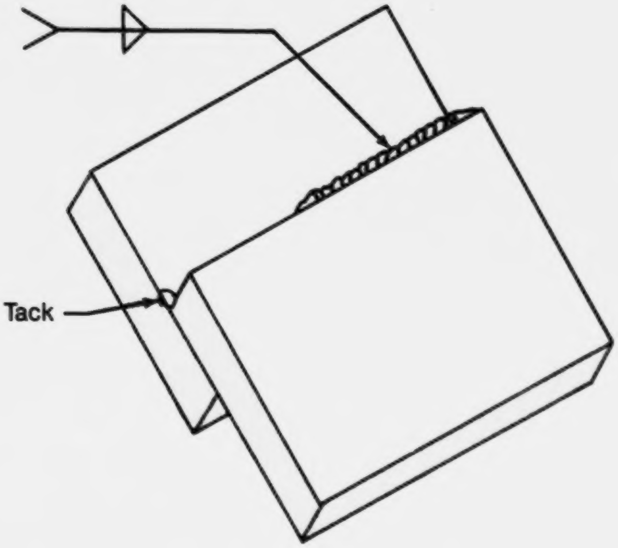
L. Withdraw rod about 1/2 inch to 3/4 inch from inner cone so that torch can be moved forward

M. Advance puddle forward with a slight circular motion of torch, and reinsert rod into center of puddle at point of inner cone and let a drop or two of molten metal fill puddle as you move rod in a circular motion

N. Withdraw rod, advance torch in a circular motion so that a continuous oval-shaped puddle is formed, then reinsert rod as before and continue technique until weld is completed (Figure 15)

(NOTE: In the following illustration, the AWS welding symbol for this joint has been added so you can become used to associating welding symbols with the welds they represent.)

FIGURE 15



O. Stop before reaching the end joint so molten metal will not drip off edge

P. Turn off torch and shut down equipment

Q. Have instructor check and evaluate your work and check for proper shutdown

R. Cool and place all welded scrap material in a proper container, and clean area as required

S. Check in tools and equipment, or prepare for next project as directed by instructor

Project Guide #8 adapted with permission of Mid-America Vocational Curriculum Consortium, Stillwater, Oklahoma.

## PROJECT GUIDE #9 — Weld a Tee Joint in Flat Position Using Mild Steel

PURPOSE: To allow you to develop skill in joining metals using the tee-joint method on mild steel. You will also gain skill in controlling the torch, selecting filler rod, and adjusting oxyacetylene equipment.

REFERENCE MANUALS:

A. EA-ITP-AB

B. AC 65-15A

C. *Welding, Cutting, and Heating Guide*

EQUIPMENT AND TOOLS:

A. Oxyacetylene welding unit

B. Protective clothing

C. Welding gloves

D. Welding goggles

E. Pliers

F. Spark lighter

G. Large C-clamp

SUPPLIES AND MATERIALS:

A. Mild steel plates as selected by instructor

B. Mild steel welding rod as selected by instructor

PROCEDURE:

A. Check work area to make sure it is free of flammable materials and is well ventilated, and note nearest location of fire extinguisher

B. Check thicknesses of workpieces, select proper tip, and place and tighten tip onto welding torch finger tight

C. Determine regulator pressures required; set up and purge regulators and lines

D. Check joint to make sure it is properly prepared and properly fitted

E. Put on welding gloves and welding goggles

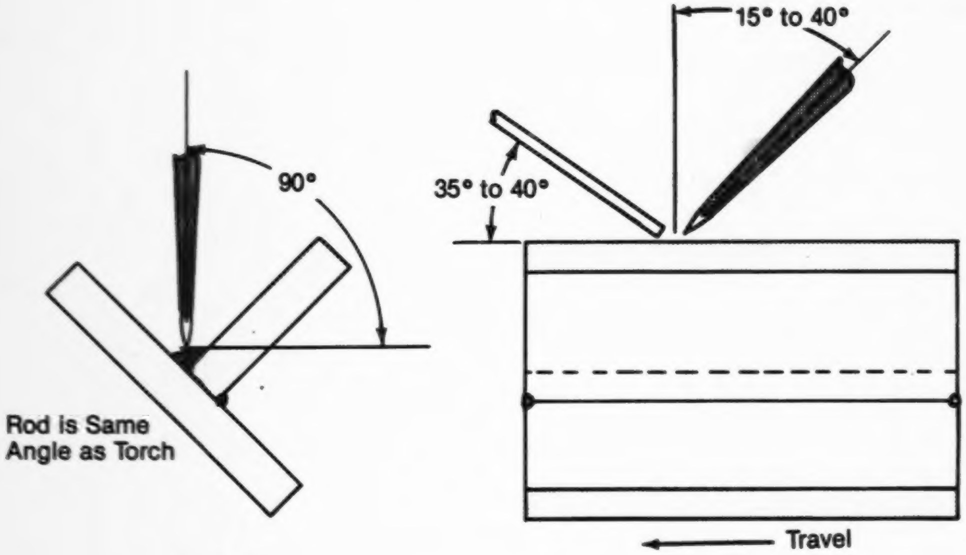
F. Light torch and adjust to neutral flame

G. Hold torch comfortably with one hand and filler rod with other hand, and use forehand welding technique

H. Tack weld joint at each end

I. Position torch and rod so that torch flame points toward unfinished end of weld and rod points toward finished end of weld (Figure 16)

FIGURE 16



Side View

Front View

J. Move torch down until inner cone of flame is about 1/8 inch from surface of metal, and hold it there until a small pool of molten metal forms, then begin a slight circular movement with torch

K. Move rod into center of puddle at point of inner cone and let a drop or two of molten metal fill puddle as you move rod in a slight circular motion

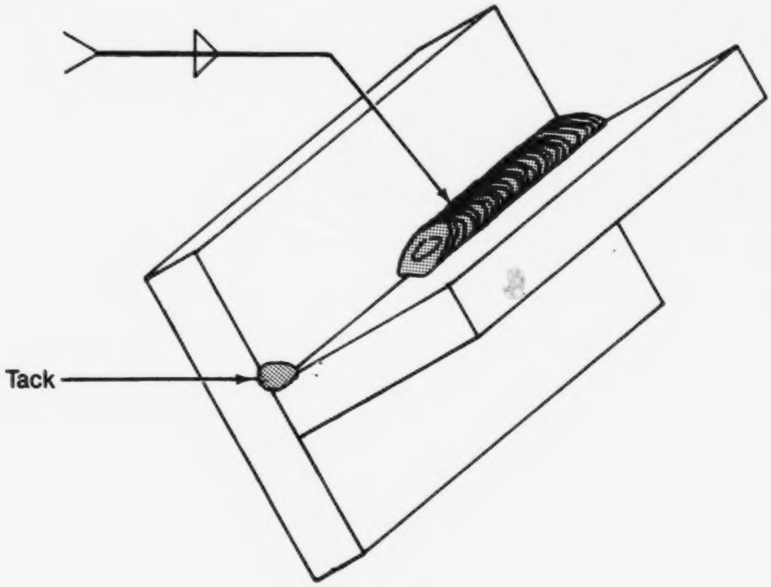
L. Withdraw rod about 1/2 inch to 3/4 inch from inner cone so that torch can be moved forward

M. Advance puddle forward with a slight circular motion of torch, and reinsert rod into center of puddle at point of inner cone and let a drop or two of molten metal fill puddle as you move rod in a circular motion

N. Withdraw rod, advance torch in a circular motion so that a continuous oval-shaped puddle is formed, then reinsert rod as before and continue technique until weld is completed (Figure 17)

(NOTE: In the following illustration, the AWS welding symbol for this joint has been added so you can become used to associating welding symbols with the welds they represent.)

FIGURE 17



O. Stop before reaching end of joint so molten metal will not drip off edge

P. Turn off torch and shut down equipment

Q. Have instructor check and evaluate your work and check for proper shutdown

R. Cool and place all welded scrap material in a proper container, and clean area as required

S. Check in tools and equipment, or prepare for next project as directed by instructor

Project Guide #9 adapted with permission of Mid-America Vocational Curriculum Consortium, Stillwater, Oklahoma.

## AIRFRAME
## A204 AIRCRAFT WELDING
## PERFORM GAS WELDING AND CUTTING
## A204-A

### PROJECT GUIDE #10 — Inspect Condition of Completed Welds

PURPOSE: To allow you to gain skill in evaluating welds which have been completed using the oxyacetylene process.

REFERENCE MANUALS:

A. AC 65-9A

B. *Welding, Cutting, and Heating Guide*

EQUIPMENT AND TOOLS:

A. Bench vise

B. Ball peen hammer

C. 10× magnifying glass

D. Soft wire brush

E. Vise-grip pliers

PROCEDURE:

A. Clean all welds

(NOTE: A soft wire brush may be used to help clean welds if necessary.)

B. Inspect all welds visually using 10× magnifying glass for features consistent with good welds

C. Record all discrepancies found during inspection on discrepancy list

D. Clamp welded joints, one at a time, in bench vise

E. Hammer and bend with ball peen hammer and vise-grip pliers until breakage occurs

F. Record findings related to any breakage occurring to welded joints on breakage list

G. Clean work area, and return tools and equipment to proper storage area

## PROJECT GUIDE #10

Discrepancy list

1. ________________________________________

2. ________________________________________

3. ________________________________________

4. ________________________________________

5. ________________________________________

6. ________________________________________

7. ________________________________________

8. ________________________________________

# PROJECT GUIDE #10

9.

10.

**Breakage list**

1.

2.

3.

4.

5.

6.

## PROJECT GUIDE #10

7. ______________________________

______________________________

______________________________

8. ______________________________

______________________________

______________________________

9. ______________________________

______________________________

______________________________

10. ______________________________

______________________________

______________________________

# AIRFRAME
# A204 AIRCRAFT WELDING
# PERFORM GAS WELDING AND CUTTING
# A204-A

## THEORY TEST

1. Match terms related to gas welding and cutting to their correct definitions. Write the correct numbers in the blanks.

_____a. Fire inside torch

_____b. Term usually applied to rust, corrosion, coating, film, or scale

_____c. Metal being welded

_____d. Invisible rays of light which occur outside the violet end of the visible spectrum

_____e. Mixture with metallic properties composed of two or more elements of which one is a metal

_____f. Distance from the original surface of the base metal to that point at which fusion ceases

_____g. To cleanse a system by flushing

_____h. Concave junction formed where two surfaces meet

_____i. Metal such as aluminum or magnesium which reacts with oxygen to form corrosion

_____j. Short weld used for temporarily holding material in place

_____k. Momentary burning back of the flame into the tip

_____l. A more or less completely fused and vitrified matter which separates from a metal in the process of its reduction in the melting furnace

1. Reactive metal
2. Penetration
3. Slag
4. Ultraviolet rays
5. Flashback
6. Tack weld
7. Base metal
8. Purge
9. Oxide
10. Backfire
11. Alloy
12. Fillet

## THEORY TEST

______m. Thermal radiation of wavelengths longer than those of visible light

______n. Material used to cover the pool of molten metal in the process of welding

______o. Dimensionless number relating to the amount of dimensional change of a material with a change in temperature

______p. Inner white part of the neutral flame

______q. Joining pieces of metal by heating the adjoining edges to the fusion or melting point and allowing them to flow or run together and then cool

13. Inner cone
14. Flux
15. Fusion welding
16. Infrared rays
17. Coefficient of expansion

2. The first and most important consideration when working on aircraft or aircraft parts with oxyacetylene welding or cutting equipment is to handle and use all equipment safely. The following list is composed of safe and unsafe practices. Discriminate between safe and unsafe practices related to the handling and use of oxygen, acetylene, and oxyacetylene welding equipment. Place an "S" in the blanks before the safe practices and a "U" in the blanks before the unsafe practices.

______a. Shut off cylinder valves when not in use for any length of time to reduce the possibility of leakage and strain on the equipment

______b. Keep hands, gloves, and clothing free from oil and grease

______c. Test connections for leaks with Ivory soapsuds, paintbrush, and water

______d. Never open the acetylene cylinder valve more than two turns

______e. Have $CO_2$ or dry-powder-type fire extinguisher available

______f. Use safety goggles, gloves, and protective clothing

______g. Open cylinder valves quickly

______h. Turn off oxygen torch valve first

______i. Never leave a burning torch unattended

______j. Stand to the side of regulators, keeping the cylinder valve between operator and regulator, when opening cylinder valves

______k. Use oxygen as a substitute for compressed air

______l. Avoid lighting torch, cutting, or welding near combustible materials _____m. Always operate torch in a well-ventilated area

_____n. Place steel caps on all gas cylinders when they are being moved or stored to protect the valves

_____o. Purge oxygen and acetylene passages (at the same time) before lighting torch

_____p. Avoid breathing toxic fumes when cutting or welding

_____q. Never cut or weld too close to concrete (masonry)

_____r. It is safe to use acetylene (in free state) at pressures higher than 15 psi

_____s. Support oxygen and acetylene cylinders in an upright position so they cannot be tipped over

_____t. Release pressure adjusting screw on regulator before opening cylinder valve in order to prevent damage to regulators and possible injury to operator

_____u. Blow out cylinder valves (crack cylinder valves for a second before attaching regulators) in order to remove dust and dirt that may damage regulators

_____v. Light acetylene before opening oxygen torch valve

_____w. Never cut containers that have been used for combustible materials

_____x. Always protect hoses from hot metal, rupture, or mechanical damage

_____y. Aways light torch with a butane lighter

_____z. Always weld or cut at least five feet from cylinders

_____aa. Use oil or grease on regulators, torches, or fittings

3. Knowledge of the characteristics of the most common gases used in gas welding and cutting will substantially add to the safety margin when working in this area. This knowledge will also ensure that the best materials are used for the job. Match the gases hydrogen, oxygen, and acetylene to their proper characteristics. Write the correct numbers in the blanks.

| | |
|---|---|
| _____a. A colorless gas slightly lighter than air, with a strong and rather disagreeable odor | 1. Acetylene |
| _____b. Stored in steel cylinders under a pressure of more than 2,000 psi | 2. Hydrogen |
| _____c. If ignited, the result is a yellow, smoky flame with a low temperature | 3. Oxygen |
| _____d. If this is added to an acetylene flame which has a relatively low temperature, the flame will suddenly become an extremely hot flame | |
| _____e. This gas is made by adding water to calcium carbide crystals | |

## THEORY TEST

______f. It in itself is not combustible; unites with other materials to increase their rate of burning

______g. Does not exist free in the atmosphere; it must be manufactured

______h. The most abundant substance on earth

______i. When it is burned in the air, it produces a white light because of the extremely large amount of carbon it contains

______j. The temperature of the flame is not as high as that produced by acetylene

______k. This gas is used for welding aluminum and magnesium because it produces a very clean flame

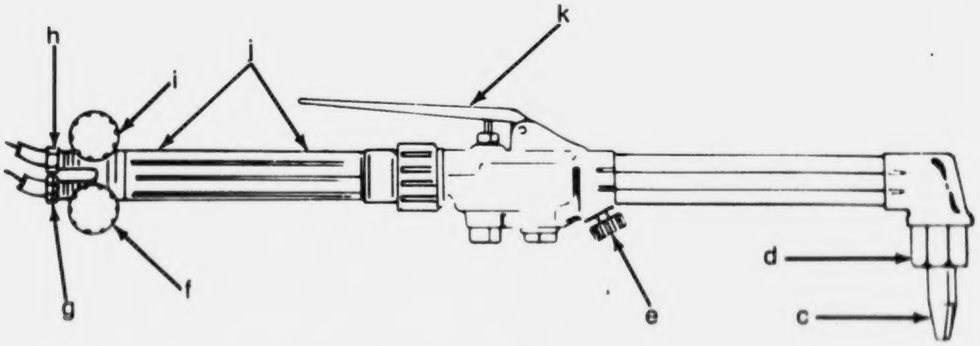
______l. A stable compound when it is not under pressure, but if stored under a pressure of more than about 15 psi, it becomes unstable

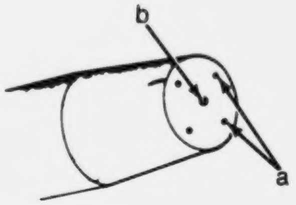
______m. If it comes in contact with oil or grease or almost any other petroleum product, it will combine with it rapidly enough to generate sufficient heat to ignite

1. Acetylene
2. Hydrogen
3. Oxygen

# THEORY TEST

4. Knowing the parts of the cutting torch will make your job of cutting much easier and safer. Label parts of a torch body and cutting attachment. Write the correct names in the blanks.





a. ______________________________

b. ______________________________

c. ______________________________

d. ______________________________

e. ______________________________

f. ______________________________

g. ______________________________

h. ______________________________

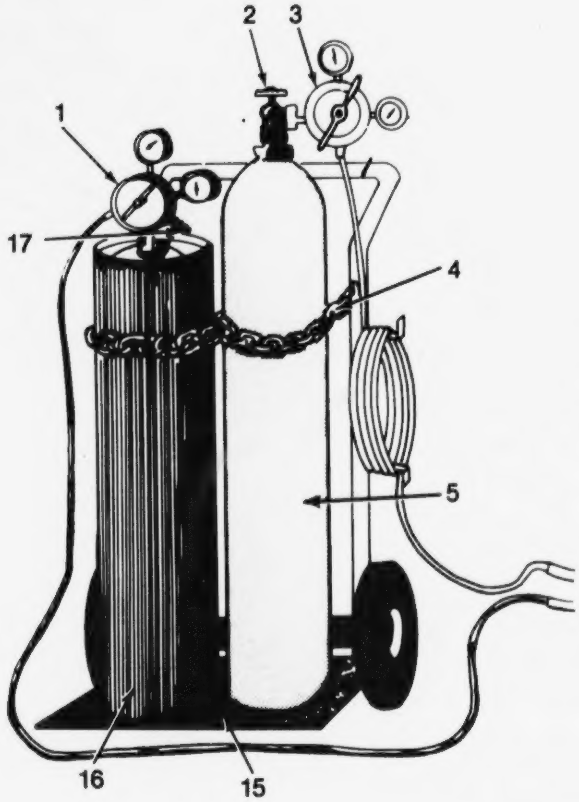
i. ______________________________

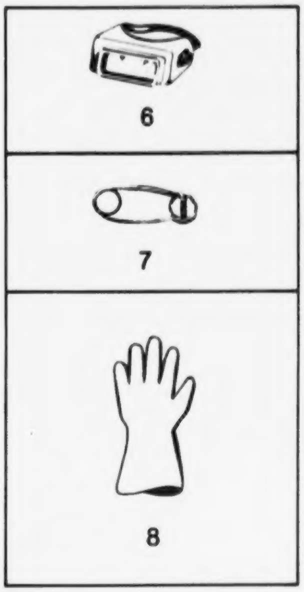
j. ______________________________

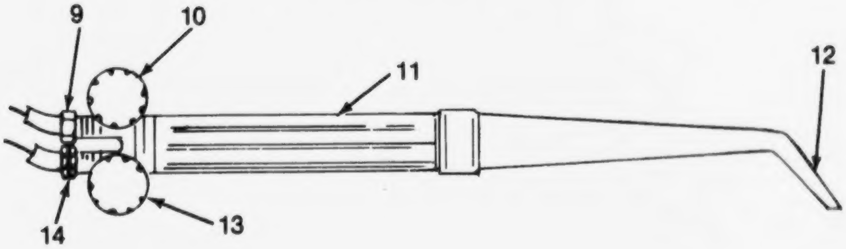
k. ______________________________

THEORY TEST

5. Identify oxyacetylene welding equipment. Write the correct numbers in the blanks on the following page.


2
3
1
17
4
5
16
15




9
10
11
12
14
13

## THEORY TEST

______a. Welding gloves

______b. Cylinder truck

______c. Oxygen cylinder

______d. Flint lighter

______e. Acetylene torch valve

______f. Acetylene cylinder valve

______g. Torch body

______h. Acetylene fitting (hex-grooved nut, left-hand threads)

______i. Welding goggles

______j. Acetylene regulator

______k. Safety chain

______l. Welding tip

______m. Oxygen fitting (right-hand threads)

______n. Acetylene cylinder

______o. Oxygen torch valve

______p. Oxygen regulator

______q. Oxygen cylinder valve

6. A backfire is a somewhat common occurrence in an oxyacetylene welding and cutting shop. List the causes of a backfire.

a. ________________________________________

b. ________________________________________

c. ________________________________________

d. ________________________________________

e. ________________________________________

## THEORY TEST

7. List the most common results of a backfire.

a. ______________________________

b. ______________________________

c. ______________________________

d. ______________________________

8. A flashback means that something is terribly wrong. Describe how to recognize the occurrence of a flashback.

______________________________

______________________________

______________________________

______________________________

9. The aircraft maintenance technician must act immediately if a flashback occurs. There are a number of steps to perform and an order to follow relative to the circumstances of the flashback. List in proper order the steps to follow if a flashback occurs while cutting metal with the oxyacetylene rig.

a. ______________________________

______________________________

b. ______________________________

______________________________

c. ______________________________

______________________________

d. ______________________________

______________________________

e. ______________________________

______________________________

______________________________

______________________________

______________________________

______________________________

f. ______________________________

______________________________

10. An aircraft welder must know how to alter his procedures to rectify any abnormalities which occur on his weld. To do this the welder must know what factors determine fusion weld quality. Name factors that determine fusion weld quality.

a. ______________________________

b. ______________________________

c. ______________________________

d. ______________________________

e. ______________________________

11. Having the correct tip size and the correct type and size of filler rod will produce ease in weldability and will promote strength. Name factors that determine tip size and factors that determine type and size of filler rod to be used in oxyacetylene welding.

**Factors that determine tip size**

a. ______________________________

b. ______________________________

**Factors that determine type and size of filler rod**

a. ______________________________

b. ______________________________

12. State the primary purpose for using a filler rod.

______________________________

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## THEORY TEST

13. Match types of welding flames to their correct usages. Write the correct numbers in the blanks.

______a. Least used because it oxidizes metal, but is used for braze welding with a bronze rod

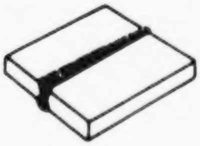
______b. The most used flame for OAW applications

______c. Used for backhand welding and for welding mild steel with low-alloy rods

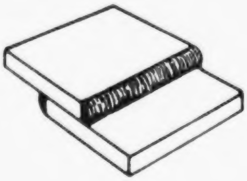
______d. Used for some hardfacing, but must be used selectively because it adds carbon to base metals

1. Carburizing
2. Neutral
3. Oxidizing
4. Reducing

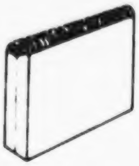
14. Label types of welding joints. Write the correct names in the blanks.



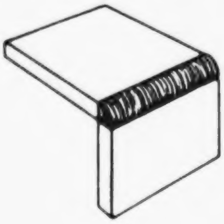
a. ______________________________



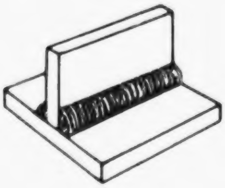
b. ______________________________



c. ______________________________



d. ______________________________



e. ______________________________

## THEORY TEST

(NOTE: Test questions 15-24 are project guides. They are an important part of this test. If they have not been completed, check with your instructor.)

15. Set up equipment for oxyacetylene cutting.

16. Turn on, light, and adjust cutting torch to neutral flame, and turn off oxyacetylene cutting equipment.

17. Cut mild steel flat plate.

18. Turn on, light, adjust, and turn off oxyacetylene welding equipment.

19. Lay beads on mild steel plate without filler rod.

20. Lay beads on mild steel plate with filler rod.

21. Weld a butt joint in flat position using mild steel.

22. Weld a lap joint in flat position using mild steel.

23. Weld a tee joint in flat position using mild steel.

24. Inspect condition of completed welds.

# AIRFRAME
# A204 AIRCRAFT WELDING
# PERFORM GAS WELDING AND CUTTING
# A204-A

## ANSWERS TO THEORY TEST

1. a. 5
b. 9
c. 7
d. 4
e. 11
f. 2
g. 8
h. 12
i. 1
j. 6
k. 10
l. 3
m. 16
n. 14
o. 17
p. 13
q. 15

2. a. S
b. S
c. S
d. U
e. S
f. S
g. U
h. S
i. S
j. S
k. U
l. S
m. S
n. S
o. U
p. S
q. S
r. U
s. S
t. S
u. S
v. S
w. S
x. S
y. U
z. S
aa. U

3. a. 1
b. 3
c. 1
d. 3
e. 1
f. 3
g. 1
h. 3
i. 1
j. 2
k. 2
l. 1
m. 3

4. a. Preheat orifices
b. Cutting orifice
c. Slip-in tip
d. Tip nut
e. Oxygen preheat valve
f. Acetylene torch valve
g. Acetylene fitting (hex-grooved nut, left-hand threads)
h. Oxygen fitting (right-hand threads)
i. Oxygen torch valve
j. Torch body
k. Oxygen cutting lever

5. a. 8
b. 15
c. 5
d. 7
e. 13
f. 17
g. 11
h. 14
i. 6
j. 1
k. 4
l. 12
m. 9
n. 16
o. 10
p. 3
q. 2

## ANSWERS TO THEORY TEST

6. a. Insufficient acetylene or oxygen pressure
   b. Loose torch tip
   c. Dirty tip
   d. Overheating of cutting tip
   e. Bad O-ring in torch body

7. a. Flame burns momentarily back into tip
   b. A loud snap or pop results
   c. Flame may go out
   d. Flame may continue to burn in normal manner

8. Disappearance of flame followed by squealing or hissing noise inside torch, sparks coming from the torch, smoke coming from the torch

9. a. Do not panic
   b. Close oxygen preheat valve
   c. Close oxygen torch valve
   d. Close acetylene torch valve
   e. Shut off oxygen cylinder valve first and then the acetylene cylinder valve unless you see the hose flame heading right for the acetylene cylinder; if it is, you will have to quickly decide either to turn off the cylinder valve or to run
   f. Disassemble, inspect, and replace any damaged equipment before relighting

10. a. Proper flame adjustment
    b. Angle of tip
    c. Distance from work
    d. Speed of travel
    e. Movement of tip

11. **Factors that determine tip size**

    a. Metal thickness
    b. Size of welding rod

    **Factors that determine type and size of filler rod**

    a. Rod with similar properties as base metal
    b. Thickness of metal

## ANSWERS TO THEORY TEST

12. To add strength to weld or joint

13. a. 3
    b. 2
    c. 4
    d. 1

14. a. Butt
    b. Lap
    c. Edge
    d. Corner
    e. Tee

15. Performance skills evaluated to the satisfaction of the instructor

16. Performance skills evaluated to the satisfaction of the instructor

17. Performance skills evaluated to the satisfaction of the instructor

18. Performance skills evaluated to the satisfaction of the instructor

19. Performance skills evaluated to the satisfaction of the instructor

20. Performance skills evaluated to the satisfaction of the instructor

21. Performance skills evaluated to the satisfaction of the instructor

22. Performance skills evaluated to the satisfaction of the instructor

23. Performance skills evaluated to the satisfaction of the instructor

24. Performance skills evaluated to the satisfaction of the instructor

MODULE OF INSTRUCTION
FOR
AVIATION MAINTENANCE TECHNOLOGY

# AIRFRAME
# A204 AIRCRAFT WELDING
# PERFORM BRAZING AND SOLDERING
## A204-B

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  4. Project Guide #4 — Solder Wire Splices

H. Theory Test

I. Answers to Theory Test

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## INTRODUCTION

The aviation maintenance technician must develop some skills which are specialized and not often used. Nevertheless, these skills are necessary and very important to the overall maintenance of aircraft. Brazing and soldering are these types of skills. Learn the skills and processes taught in this module and you will be able to join metals which could not otherwise be joined and you will be able to construct strong, conductive electrical connections.

## MODULE OBJECTIVE

After completion of this module, you will be able to weld a stringer bead with a bronze rod on steel plate, braze weld a butt joint in flat position, and prepare a soldering tip iron for use. You will also be able to solder wire splices. Your competency will be evaluated by completing workbook assignments and project guides, and by scoring a minimum of 85 percent on the module theory test.

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## SPECIFIC OBJECTIVES

After completion of this module, you will be able to:

| | | |
|---|---|---|
| 1. Match terms related to oxyacetylene braze welding, brazing, and soldering to their correct definitions. (1) | Technical Supplement #1<br>Workbook Supplement #1 | |
| 2. Differentiate between fusion welding and braze welding when given related data. (2) | Technical Supplement #2<br>AC 65-15A<br>Workbook Supplement #1 | <br>264<br> |
| 3. Describe brazing and braze welding processes. (2) | Technical Supplement #2<br>EA-ITP-AB<br>AC 65-15A<br>Workbook Supplement #1 | <br>200<br>264-265<br> |
| 4. Select true statements concerning the advantages of braze welding and brazing. (1) | Technical Supplement #2<br>EA-ITP-AB<br>AC 65-15A<br>Workbook Supplement #1 | <br>200<br>264<br> |
| 5. Select true statements concerning the limitations of braze welding and brazing. (1) | Technical Supplement #2<br>AC 65-15A<br>Workbook Supplement #1 | <br>264<br> |
| 6. Explain why tinning is important and how tinning is accomplished in braze welding and brazing. (1) | Technical Supplement #2<br>Workbook Supplement #1 | |
| 7. Select true statements concerning the purposes of flux. (1) | Technical Supplement #3<br>EA-ITP-AB<br>AC 65-15A<br>Workbook Supplement #1 | <br>200<br>264<br> |
| 8. Select true statements concerning the characteristics of filler rods for braze welding and brazing. (1) | Technical Supplement #3<br>Workbook Supplement #1 | |
| 9. State the three most important factors in successful braze welding. (1) | Technical Supplement #4<br>Workbook Supplement #1 | |
| 10. Select true statements concerning joint preparation for braze welding. (1) | Technical Supplement #4<br>EA-ITP-AB<br>AC 65-15A<br>Workbook Supplement #1 | <br>200<br>264<br> |

## SPECIFIC OBJECTIVES

| | | |
|---|---|---|
| 11. State the three methods used to remove oxides in joint preparation for braze welding or brazing. (1) | Technical Supplement #4<br>Workbook Supplement #1 | |
| 12. Select true statements concerning techniques for braze welding steel. (1) | Technical Supplement #4<br>EA-ITP-AB<br>AC 65-15A<br>Workbook Supplement #1 | <br>200<br>264-265<br> |
| 13. Select true statements concerning techniques for brazing. (1) | Technical Supplement #4<br>EA-ITP-AB<br>AC 65-15A<br>Workbook Supplement #1 | <br>200<br>264-265<br> |
| 14. Match brazing and braze welding problems to their causes. (1) | Technical Supplement #4<br>Workbook Supplement #1 | |
| 15. Weld a stringer bead with a bronze rod on steel plate. (2) | Project Guide #1 | |
| 16. Braze weld a butt joint in flat position. (2) | Project Guide #2 | |
| 17. Differentiate between brazing and soldering. (2) | EA-ITP-AB<br>Workbook Supplement #2 | 200<br> |
| 18. List three purposes of soldering in aircraft maintenance. (1) | Technical Supplement #5<br>EA-ITP-AB<br>AC 65-15A<br>Workbook Supplement #2 | <br>200<br>265<br> |
| 19. Discuss the guidelines for keeping soldering coppers clean. (2) | Technical Supplement #5<br>AC 65-15A<br>Workbook Supplement #2 | <br>265<br> |
| 20. Match process names to processes used in maintaining soldering coppers. (1) | Technical Supplement #5<br>Workbook Supplement #2 | |
| 21. Discuss characteristics of solder. (2) | Technical Supplement #5<br>EA-ITP-AB<br>AC 65-15A<br>Workbook Supplement #2 | <br>201<br>265<br> |
| 22. Select true statements concerning soldering flux and its characteristics. (1) | Technical Supplement #5<br>EA-ITP-AB<br>Workbook Supplement #2 | <br>201<br> |

## SPECIFIC OBJECTIVES

| | | |
|---|---|---|
| 23. Select true statements concerning flame soldering and its technique. (1) | Technical Supplement #5 | |
| | EA-ITP-AB | 200-201 |
| | AC 65-15A | 264-265 |
| | EA-ITP-AW | 3:17-18 |
| | Workbook Supplement #2 | |
| 24. Prepare a soldering iron tip for use. (2) | Project Guide #3 | |
| 25. Solder wire splices. (2) | Project Guide #4 | |

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## INSTRUCTOR'S MODULE IMPLEMENTATION GUIDE

I. Order materials to supplement module—Book: *Welding Skills and Technology*.

(NOTE: This book is available from McGraw-Hill Book Co., 13955 Manchester Road, Manchester, MO 63011.)

II. Implementation Suggestions

(NOTE: Have students read all available resource material related to specific objectives.)

| Estimated Teaching Time | | Theory | Lab |
|---|---|---|---|
| Objective 1 | Use Technical Information Supplement #1 to aid in discussing terms and definitions related to oxyacetylene brazing, braze welding, and soldering. Use as many illustrations and material examples as possible. | | |
| Objective 2 | Point out the difference between fusion welding, which was studied in A204-A, and braze welding. Be sure to include in your explanation a comparison of tools, materials, and techniques which the technician uses in these processes. Use Technical Information Supplement #2. | | |
| Objective 3 | Describe the brazing and braze welding processes. Show examples of materials joined by brazing and braze welding. Be sure students understand how capillary action creates a brazed joint, and how gravity and molecular attraction create a braze weld. Use Transparency Masters #1 and #2 and Technical Information Supplement #2. | | |

## INSTRUCTOR'S MODULE IMPLEMENTATION GUIDE

| Estimated Teaching Time | | Theory | Lab |
|---|---|---|---|
| Objectives 4-5 | Create two lists on the blackboard or flip charts. One list will be the advantages of brazing and braze welding; the other will contain the limitations of these processes. Be sure to explain all aspects of the advantages and limitations. Use Technical Information Supplement #2. | | |
| Objective 6 | Describe the tinning action which occurs during brazing and braze welding. Explain why this tinning action is important. Give a demonstration of this action. Have students review Technical Information Supplement #2 and administer an oral quiz afterward. | | |
| Objective 7 | Explain the purpose of flux in the brazing process. Show examples of the most common types of flux. Use Technical Information Supplement #3. | | |
| Objective 8 | Show the different types of filler rods used in braze welding and brazing and explain their different characteristics. Have the students review Technical Information Supplement #3 and administer a short oral quiz. | | |
| Objective 9 | Name the three most important factors concerning the joining of metals by braze welding. Be sure the students understand the result if these factors are not properly considered. Show examples of braze welding where these factors were not considered. Use Technical Information Supplement #4. | | |
| Objective 10 | Explain how a joint is prepared for braze welding. If possible, show examples of joints which can be brazed. Use Transparency Masters #3 - #5 and Technical Information Supplement #4. | | |

## INSTRUCTOR'S MODULE IMPLEMENTATION GUIDE

| Estimated Teaching Time | | Theory | Lab |
|---|---|---|---|
| Objective 11 | State the three methods used to remove oxides from the metal to be joined. Demonstrate mechanical and chemical removal of oxides from metal. Use Technical Information Supplement #4. | | |
| Objectives 12-13 | Explain how a technician braze welds and brazes steel. Use Transparency Masters #6 - #8 and Technical Information Supplement #4. | | |
| Objective 14 | List the problems associated with brazing and braze welding, their causes, and their remedies. Have the class review Technical Information Supplement #4. Have the class complete Workbook Supplement #1 using textbooks, EA-ITP-A and AC 65-15A. Some of the questions in this workbook supplement can be answered only by reference to the technical information supplements. Workbook Supplement #1 should be completed after you have tested student recall of your explanations and students have thoroughly researched the textbooks. | | |
| Objectives 15-16 | Discuss Project Guides #1 and #2 as a class before entering the shop. Be sure to review all pertinent safety rules and precautions. Demonstrate all brazing techniques and processes before allowing students to practice. Have the students complete the projects. Review the projects in class after all students have completed their work. | | |
| Objective 17 | Point out the differences between brazing and soldering. Be sure to mention tool, material, and process differences which would be helpful when differentiating between the two processes. | | |

# INSTRUCTOR'S MODULE IMPLEMENTATION GUIDE

| Estimated Teaching Time | | Theory | Lab |
|---|---|---|---|
| Objective 18 | State the three main purposes for soldering in aircraft maintenance. Mention the main applications for soldered joints in aviation. Use Technical Information Supplement #5. | | |
| Objectives 19-20 | Explain how to prepare and maintain soldering coppers for soldering. Have the different types of soldering tools available for the students to examine. Use Technical Information Supplement #5. | | |
| Objectives 21-22 | Discuss solder and flux used in the soldering process. Show the different types of approved solder and flux available for use in aircraft maintenance. Be sure to emphasize when acid core solders are not used. Use Technical Information Supplement #5. | | |
| Objective 23 | Discuss the technique of flame soldering and related precautions. Have the students complete Workbook Supplement #2 and review Technical Information Supplement #5. Have the students answer the questions in EA-ITP-AW, pages 17 and 18. | | |
| Objectives 24-25 | Complete Project Guides #3 and #4 using the same procedures outlined in Objectives 15 and 16. | | |

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## TECHNICAL INFORMATION SUPPLEMENT #1 — Terms and Definitions

A. Tinning — The process of placing a thin film of filler metal along the joint of a preheated base metal

B. Flux — A chemical in paste or powder form used to clean metals, protect from oxidation, and promote fusion in a welding process

C. Oxidation — The chemical reaction of a metal with oxygen in the air, a process that promotes contamination of metal surfaces and eventually leads to rust

D. Scale — Contaminants that form in flaky configurations on the surface of a metal, usually the result of oxidation

E. Oxidizing flame — A flame with more oxygen than a neutral flame

F. Carburizing flame — A flame with more acetylene than a neutral flame

G. Neutral flame — A flame with a proportional amount of oxygen and acetylene whereby the burning oxidizes all particles of carbon and hydrogen in the acetylene

H. Capillary action — The action by which the surface of a liquid, where it is in contact with a solid, is elevated or depressed depending on the relative attraction of the molecules of the liquid

I. Solder or filler rod — A metal or metallic alloy used when melted to join metallic surfaces

J. Oxide — A chemical combination in which oxygen is combined with another element

K. Resin core flux — A translucent amber-colored to almost black brittle friable resin that is obtained by chemical means from the oleoresin or dead wood of pine trees or from tall oil and used in making soldering flux

L. Sal amoniac — A white crystalline form of ammonium chloride used as a cleaning agent in soldering; available in block or powder form

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## TECHNICAL INFORMATION SUPPLEMENT #2 — Brazing and Braze Welding

A. Difference between fusion welding and braze welding

1. In fusion welding, the filler rod has a melting point approximately the same as the base metal melting point, and both the filler metal and the base metal are melted and fused together

2. In braze welding, the filler rod has a melting point below the melting point of the base metal, the base metal is never melted, and the weld is formed as a result of the brazing metal adhering to the base metal by molecular attraction and intergranular penetration; it does not fuse with the base metal

B. Difference between brazing and braze welding

1. In brazing, the filler metal must have a melting point above 800°F, but lower than the melting point of the base metal, and the filler metal is drawn into a tight-fitting joint by capillary attraction

2. In braze welding, the filler metal must have a melting point above 800°F, but lower than the melting point of the base metal, and the filler metal is deposited into the joint by gravity pull in the joint design, not by capillary attraction

C. Advantages of braze welding and brazing

1. Braze welding is faster than fusion welding because the heat input required is less

2. Braze welding saves time and reduces fuel gas consumption

3. Braze welding minimizes preheating requirements

4. The reduction of heat input has special advantages for welding cast iron because the extremely ductile filler metal can absorb stresses as it cools

5. Due to a reduction in contraction and expansion, braze welding on steel reduces distortion of the base metal

6. Braze welding can be used to join dissimilar metals that cannot be fusion welded, such as copper to brass

7. When properly executed, braze welding steel or cast iron can produce a weld equal to or greater in strength than the original base metal

## TECHNICAL INFORMATION SUPPLEMENT #2

D. Limitations of braze welding and brazing

1. Cannot match the weld color to the color of the base metal
2. Cannot be used on metals and joints where stress is a factor
3. Will lose its strength at temperatures above 500°F
4. May have corrosion-resistant properties different from those of the base metal
5. Filler rod can be quite expensive

E. The importance of tinning in braze welding and brazing

1. The basic element of brazing and braze welding is based on the principle that brass and bronze; when raised to the proper temperature, will melt and form a smooth film (tinning) on the surface of a properly prepared and heated joint
2. Tinning cannot be properly accomplished unless the joint has been thoroughly cleaned and properly prepared
3. Good tinning usually requires a neutral to slightly oxidizing flame
4. Tinning requires a good brazing flux
5. Improper tinning action is almost always caused by overheating the base metal

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## TECHNICAL INFORMATION SUPPLEMENT #3 — Flux and Filler Rods

A. Purposes of flux

1. Chemically cleans the base metal
2. Prevents oxidation of the filler metal
3. Floats and removes the oxides already present
4. Increases the flow of the filler metal
5. Increases the ability of the filler metal to adhere to the base metal
6. Brings the filler metal into immediate contact with the metals being joined
7. Permits the filler metal to penetrate the pores of the base metal

B. Characteristics of filler rods for braze welding and brazing

1. Consists of copper alloy containing about 60 percent copper and 40 percent zinc which:
    a. Copper — produces a high tensile strength
    b. Zinc alloys — increase ductility
2. Contain small quantities of tin, iron, manganese, and silicon which help to:
    a. Deoxidize the weld metal
    b. Decrease the tendency to fume
    c. Increase the free-flowing action of the molten metal
    d. Increase the hardness of the deposited metal for greater wear resistance
3. Should be cleaned with emery cloth before use

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## TECHNICAL INFORMATION SUPPLEMENT #4 — Brazing and Braze Welding Techniques

A. Three most important factors in successful braze welding

1. Cleaning and preparation of the joint
2. Proper tinning of every bit of the joint achieved through cleaning action of the flux and proper metal temperature
3. Complete fusion between layers of filler metal when the weld is made in two or more passes

B. Joint preparation for braze welding

1. Generally, joints for braze welding are prepared the same as for fusion welding for base metals of like thickness
2. When the base metal is no thicker than 1/8-inch to 3/16-inch, square edges may be used
3. For metals thicker than 3/16-inch, beveled edges should be used
4. In all cases, every part of the base metal to be tinned must be cleaned thoroughly until it is completely free of rust, scale, oil, and grease
5. Base metal should be cleaned at least 1/2-inch back from the edge of the joint whenever possible

C. How to remove oxides in joint preparation for braze welding or brazing

1. Oxides can be removed mechanically with a wire brush or a portable grinder
2. Oxides can be removed chemically with a suitable flux
3. Sometimes cleaning requires both methods

D. Techniques for braze welding steel

1. Select a welding tip at least one size larger than would be selected for fusion welding a metal of equal thickness
2. Adjust torch to a slightly oxidizing flame

   (NOTE: Use a neutral or reducing flame for aluminum.)

3. Move the flame back and forth over a generous area of the base metal until it begins to glow dull red

4. As the base metal starts to glow dull red, heat the end of the filler rod and dip it in flux until it is well coated

   (NOTE: To flux longer rods, spread the flux out along the inside corner of a piece of angle iron so the entire length of the rod can be dipped in the flux at one time.)

5. As the base metal becomes dull red, move the rod into the flame until it comes in contact with and melts off onto the base metal

6. When the melted bronze flows smoothly onto the surface of the base metal and flows evenly over a large area, the temperature is just right

E. Techniques for brazing

1. Apply heat broadly, not in a pinpoint area

2. Use enough flux to do the job, never less

3. Use a neutral or slightly reducing flame for steel or aluminum and a slightly oxidizing flame for copper and copper base alloys

4. Use a tip which will produce a bushy flame

   (NOTE: Remember the heat of the base metal, not the torch, does the brazing.)

5. Touch the filler rod to the hot joint right on the gap (do not put directly into the flame), and if base metal is hot enough and fit-up is correct, the filler metal will flow into and around the joint

6. Always clean excess flux from joint

F. Brazing and braze welding problems and their causes

1. The molten bronze forms into drops — Base metal is not yet hot enough

2. The molten bronze tends to bubble and boil — Base metal is too hot

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## TECHNICAL INFORMATION SUPPLEMENT #5 — Soldering

A. The uses of soldering in sheet metal work

1. To provide reinforcement at points of stress where two pieces of metal are joined together

2. To provide a waterproof joint where two pieces of metal are joined together

3. To form a strong union between electrical wires that will have low electrical resistance

B. Guidelines for keeping soldering coppers clean

1. If a copper is not cleaned frequently, flux and impurities will form a scale on the tip of the copper

2. When scale accumulates on a copper, it serves to insulate the copper and prevent heat from transferring from the copper to the metal

3. Coppers can be cleaned while soldering is being done by dipping the tip of the copper into a prepared solution of sal amoniac and water

   (NOTE: This solution normally consists of a half-ounce of sal amoniac powder dissolved in a quart of water; it is inexpensive and usually discarded after use.)

4. When sal amoniac solution is not available, a steel brush can be used to clean the residue off a copper tip

C. Processes used in properly maintaining soldering coppers

1. Forging — This involves heating a copper in a furnace until the copper is cherry red, then filing off all the scale on the copper with a coarse file

2. Drawing — This involves placing the heated copper on an anvil and hammering the copper until it is drawn back to its original or near original shape

3. Filing — This involves placing the copper in a vise and dressing the corners of the point with a fine file

4. Tinning — This involves heating the copper until it is cherry red, placing the tip on a block of sal amoniac, and adding small amounts of solder while rubbing the copper on the block of sal amoniac, then turning the copper until all sides are tinned

D. Solder and its characteristics

1. Solder is made by melting tin and lead together, and is classified by the weight ratio of tin to lead
    a. 50-50 solder is 50 percent tin by weight and 50 percent lead by weight
    b. 60-40 solder is 60 percent tin by weight and 40 percent lead by weight

    (NOTE: The tin ratio is always expressed first. The two most common solders used in sheet metal work are 50-50 and 60-40.)

2. Solder is further classified as soft solder or hard solder
    a. Soft solder is used most frequently in sheet metal and electrical work
    b. Hard solder is used most frequently in brazing
3. Solder comes in bar and wire forms
    a. Solder bars range from 1/4 inch square up to 1 inch or larger, and from 12 inches to 18 inches long
    b. Wire solder comes in rolls weighing from 1/2 pound to 20 pounds and in diameters of 1/16 inch or 1/8 inch
4. Wire solder is either solid or hollow
    a. Hollow solder has either resin or acid flux in the center
    b. Solid solder requires addition of flux or acid

E. Soldering flux and its characteristics

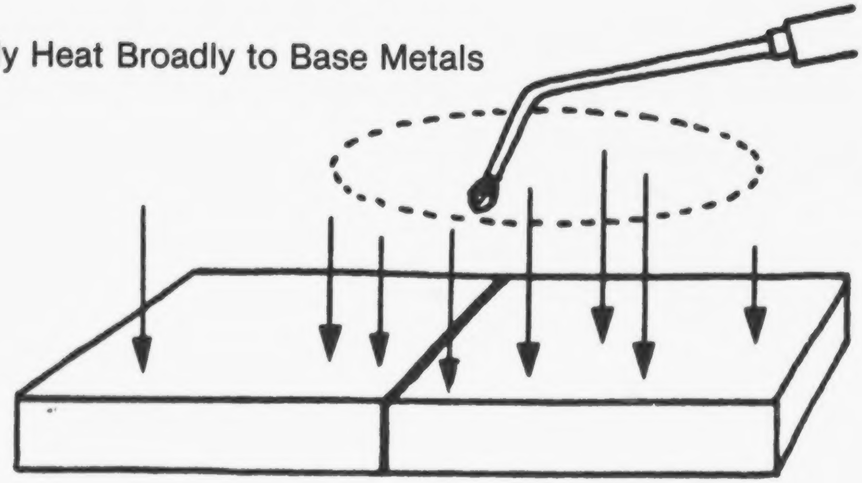
1. Flux is either acid or resin
    a. Acid flux is corrosive
    b. Resin flux is noncorrosive
2. Noncorrosive resin flux is used for soldering copper lines and in electronic/electrical applications where corrosive flux would be damaging
3. Corrosive flux is used for many sheet metal applications, but must be cleaned immediately after the job is completed

# TECHNICAL INFORMATION SUPPLEMENT #5

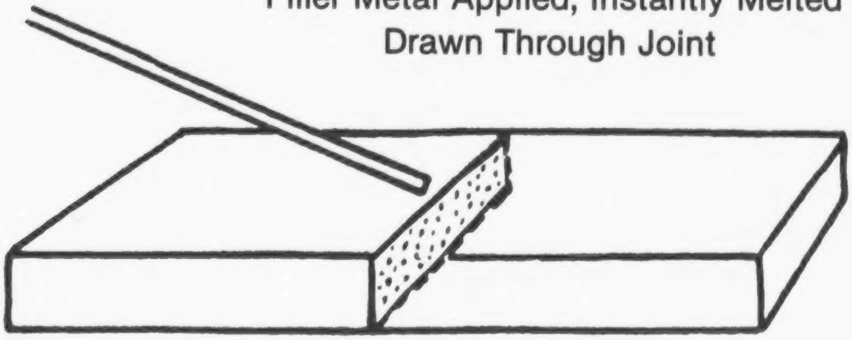
F. Flame soldering and its technique

1. Flame soldering uses a torch to melt solder instead of melting it with a soldering copper
2. Flame soldering is used in hard-to-reach places where working with a copper would be impractical
3. Flame soldering is accomplished by adjusting the torch to a desired heat, then applying heat and solder to the spot being soldered
4. As soon as the solder starts to melt, pull the torch away from the work so the metal will not overheat and burn away the tinning on the metal

# Brazing



Apply Heat Broadly to Base Metals



Filler Metal Applied, Instantly Melted and Drawn Through Joint

Capillary Force Draws Molten Brazing Metal Deep into Tight Joints

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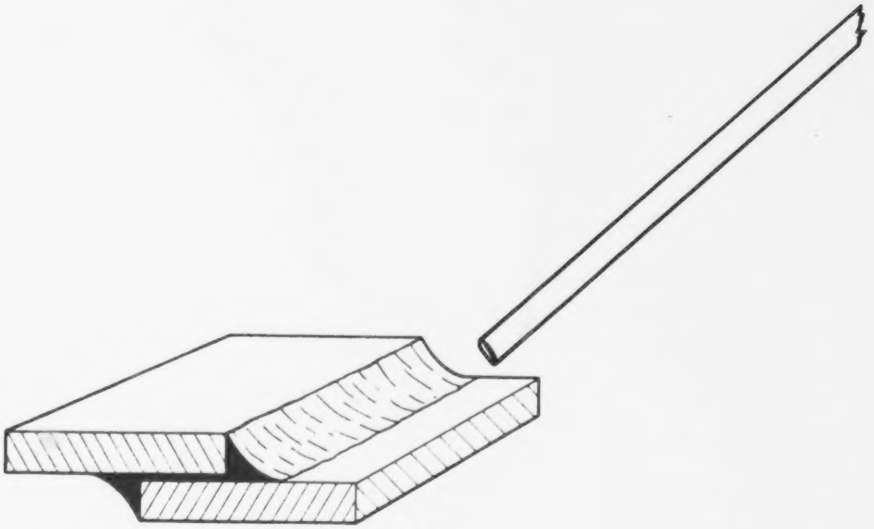
# Braze Welding

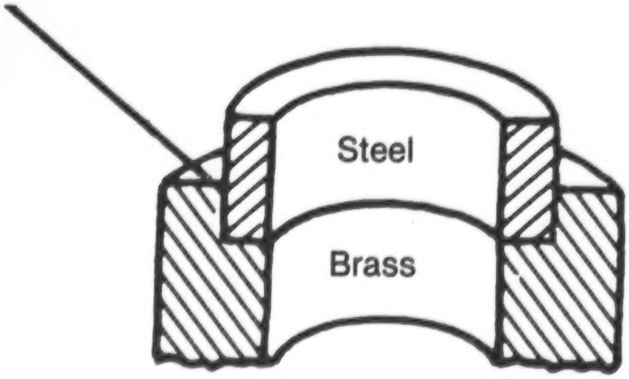


Filler Rod is Deposited on the Surface Rather Than Depending Upon Capillary Action to Produce the Joint

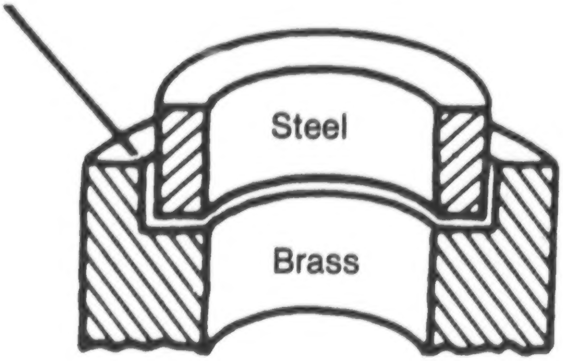
Adapted with permission of International Aviation Publishers, Inc., Riverton, Wyoming.

# Material Fit-Up

A Force Fit at Room Temperature. . .



Becomes a Suitable Gap at Brazing Temperature



Sometimes the Outside Material Will Expand at a Faster Rate Than the Inside Part of a Joint When Heated. In This Drawing, a Force Fit (Too Tight) Becomes a Good Brazing Joint at High Temperatures Because the Outside Brass Section Expands at a Faster Rate Than the Steel

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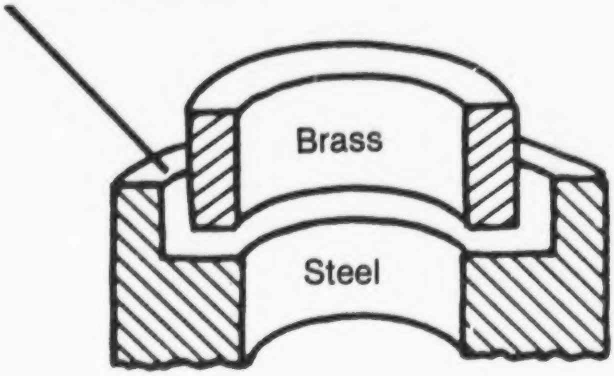
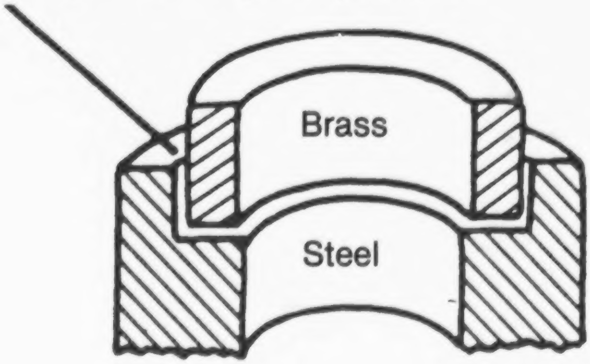
# Material Fit-Up

## (Continued)

A Wide Gap at Room Temperature. . .



Becomes a Narrow Gap at Brazing Temperature



When Materials With Different Expansion Rates Are Used, You Must Take That into Consideration. Brass, For Example, Expands More Than Steel When Heated. What Might Be a Loose Brazing Joint at Room Temperature Will Be a Perfect Joint Gap at Brazing Temperatures

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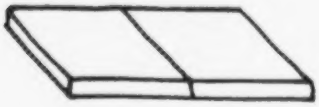
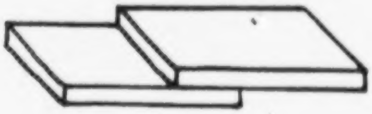
# Brazed Joints


Butt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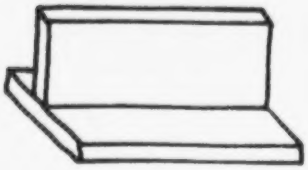
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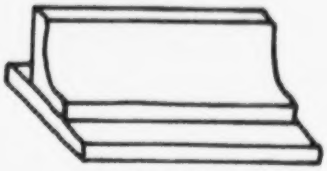
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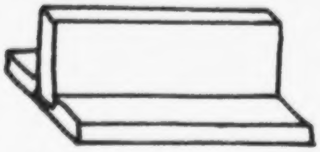
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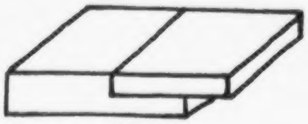
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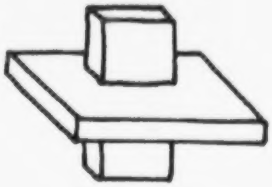
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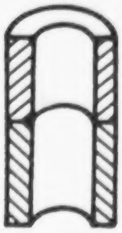
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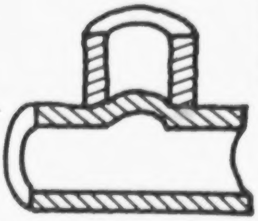
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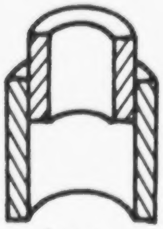
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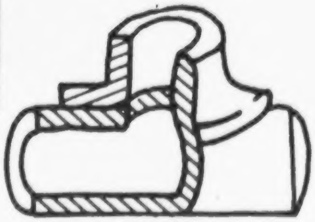
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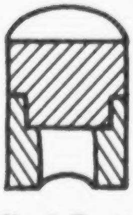
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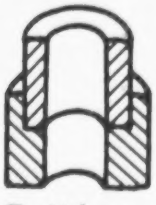
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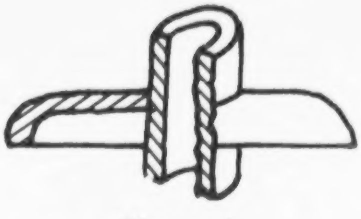
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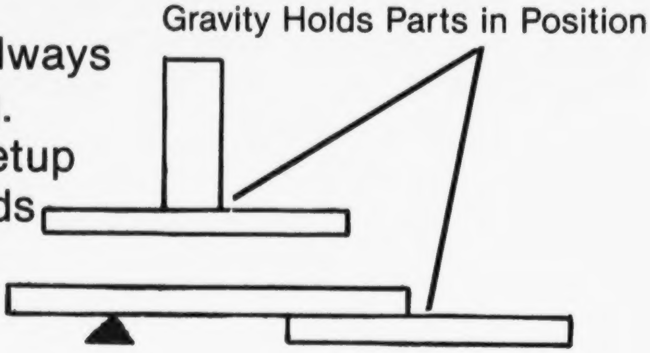
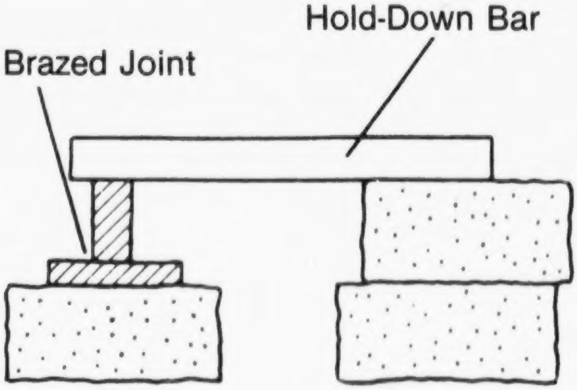
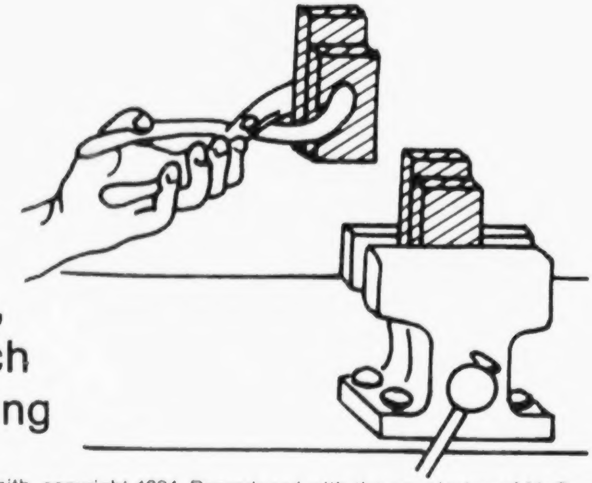
# Methods of Holding Parts for Brazing

Special Jigs and Fixtures Are Not Always Needed for Brazing. Here's a Simple Setup Where Gravity Holds the Parts in Place


Gravity Holds Parts in Position


Hold-Down Bar
Brazed Joint

This Is a Little More Elaborate Fixture Requiring Only Fire Brick and a Heavy Hold-Down Bar



A Vise, or Even Tongs, Can Be Used To Attach Many Parts For Brazing

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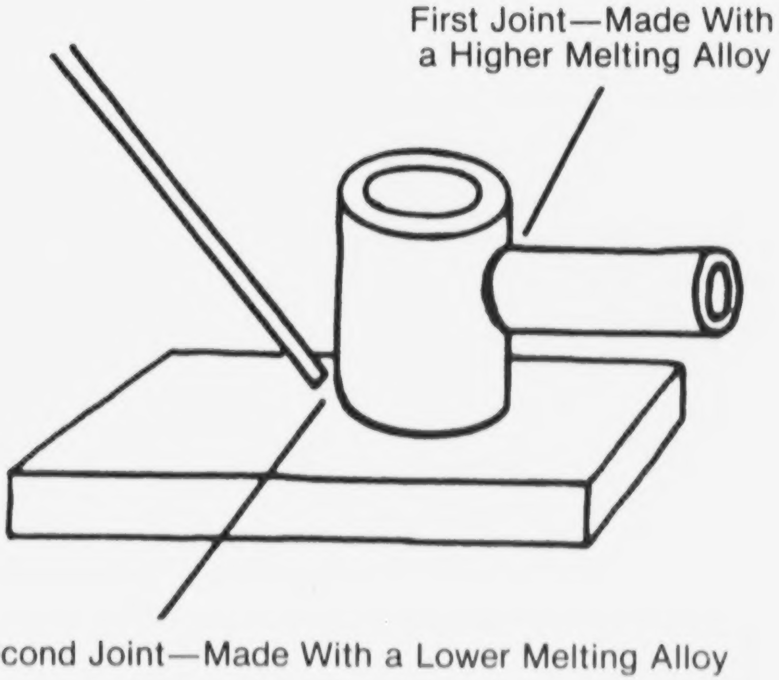
# Brazing Parts with More Than One Joint


First Joint—Made With a Higher Melting Alloy
Second Joint—Made With a Lower Melting Alloy

Parts with More Than One Joint Can Be Made with Brazing Alloys that Have Different Melting Temperatures. Make the High-Temperature Joint First, or Otherwise the Tubular Arm will Fall Off When the Second Joint Is Made

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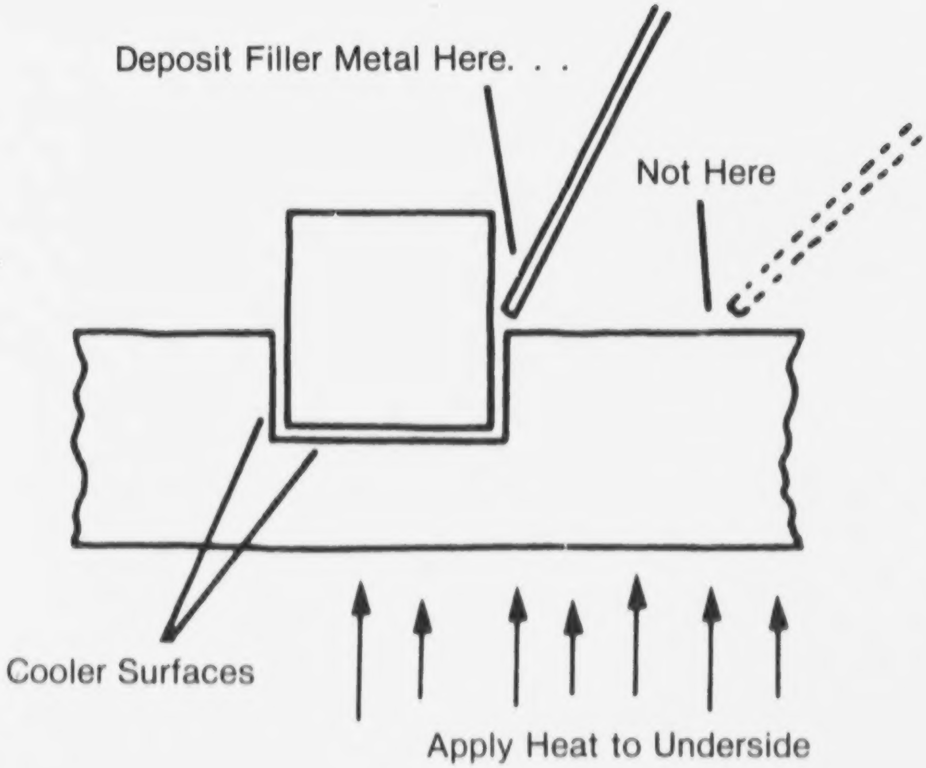
# Sweat Brazing


Deposit Filler Metal Here. . .
Not Here
Cooler Surfaces
Apply Heat to Underside

Indirect Torch Heating Is Much Better than Direct Heating for Brazed Joints. It Avoids Oxidation of the Brazing Filler Alloy If the Torch Flame Is Not Adjusted to the Neutral Condition. Indirect (Sweat) Brazing Also Avoids Overheating Low-Temperature Brazing Alloys

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# AIRFRAME
# A204 AIRCRAFT WELDING
# PERFORM BRAZING AND SOLDERING
# A204-B

## WORKBOOK SUPPLEMENT #1 — Interpret Information Related to Brazing and Braze Welding

Brazing and braze welding is a metal joining process which can be used where fusion welding is not possible, e.g. joining dissimilar metals. Aviation maintenance technicians will find that a braze weld or brazing is easily accomplished or evaluated when they have developed a knowledge of materials, processes, and principles associated with these methods of metal joining.

A. Identify the process or material which is related to the information given in the list below. Write the name for the process or material in the blank provided.

______________________ 1. A flame with more oxygen than a neutral flame

______________________ 2. A flame with a proportional amount of oxygen and acetylene whereby the burning oxidizes all particles of carbon and hydrogen in the acetylene

______________________ 3. A metal or metallic alloy used when melted to join metallic surfaces

______________________ 4. A white crystalline form of ammonium chloride used as a cleaning agent in soldering; available in block or powder form

______________________ 5. Placing a thin film of filler metal along the joint of a preheated base metal

______________________ 6. A chemical in paste or powder form used to clean metals, protect from oxidation, and promote fusion in a welding process

______________________ 7. A flame with more acetylene than a neutral flame

______________________ 8. The chemical reaction of a metal with oxygen in the air, a process that promotes contamination of metal surfaces and eventually leads to rust

________________ 9. The action by which the surface of a liquid, where it is in contact with a solid, is elevated or depressed depending on the relative attraction of the molecules of the liquid

________________ 10. Contaminants that form flaky configurations on the surface of a metal, usually the result of oxidation

________________ 11. A translucent amber-colored to almost black brittle friable resin that is obtained by chemical means from the oleoresin or dead wood of pine trees or from tall oil and used in making soldering flux

________________ 12. A flame with a proportional amount of oxygen and acetylene whereby the burning oxidizes all particles of carbon and hydrogen in the acetylene

B. State three limitations of braze welding and brazing.

1. ________________

________________

2. ________________

________________

3. ________________

________________

C. Explain the difference between fusion welding and braze welding.

1. Fusion welding — ________________

________________

________________

________________

________________

________________

2. Braze welding —

D. State four advantages of braze welding and brazing.

1.

2.

3.

4.

E. Explain the difference between brazing and braze welding.

1. Brazing —

2. Braze welding —

F. State three purposes of flux.

1.

2.

3.

G. 1. What is meant by the word "tinning"?

2. What is the usual cause of improper tinning action?

## WORKBOOK SUPPLEMENT #1

3. What type of flame does good tinning usually require? ______________________

H. 1. What do the copper and zinc alloys in brazing rods contribute to the characteristics of a braze weld?

a. Copper — ______________________

b. Zinc alloys — ______________________

2. What deoxidizes the weld metal, decreases the tendency to fume, increases the free-flowing action of the molten metal, and increases the hardness of the deposited metal for greater wear resistance of the braze weld?

______________________

I. State three important factors in completing a braze weld.

1. ______________________

2. ______________________

3. ______________________

# WORKBOOK SUPPLEMENT #1

J. 1. Select true statements concerning joint preparation for braze welding. Circle the number before each true statement.

a) Generally, joints for braze welding are prepared the same as for fusion welding for base metals of like thickness

b) When the base metal is no thicker than 1/4-inch to 1/2-inch, square edges may be used

c) For metals thicker than 3/16-inch, beveled edges should be used

d) In all cases, every part of the base metal to be tinned must be cleaned thoroughly until it is completely free of rust, scale, oil, and grease

e) Base metal should be cleaned at least 1/4-inch back from the edge of joint whenever possible

2. Correct any incorrect statements in the above list.

a) ______________________________

______________________________

______________________________

b) ______________________________

______________________________

______________________________

K. State three methods to remove oxides in joint preparation for braze welding.

1. ______________________________

______________________________

2. ______________________________

______________________________

3. ______________________________

______________________________

## WORKBOOK SUPPLEMENT #1

L. 1. Select true statements concerning techniques for braze welding steel. Circle the number before each true statement.

- a) Select welding tip at least one size larger than would be selected for fusion welding a metal of equal thickness
- b) Adjust torch to a carburizing flame
- c) Move the flame back and forth over a generous area of the base metal until it begins to glow dull red
- d) As the base metal starts to glow bright red, heat the end of the filler rod and dip it in flux until it is well coated
- e) As the base metal becomes dull red, move the rod into the flame until it comes in contact with and melts off onto the base metal
- f) When the melted bronze flows smoothly onto the surface of the base metal and flows evenly over a large area, the temperature is just right

2. Correct any incorrect statements in the list above.

a) ______________________________________________

______________________________________________

b) ______________________________________________

______________________________________________

M. 1. Select true statements concerning brazing techniques. Circle the number before each true statement.

- a) Apply heat in a pinpoint area
- b) Use enough flux to do the job, never less
- c) Use a neutral or slightly reducing flame for steel or aluminum and a slightly oxidizing flame for copper and copper base alloys
- d) Use a tip which will produce a bushy flame
- e) Touch the filler rod to the hot joint right on the gap (do not put directly into the flame), and if the base metal is hot enough and fit-up is correct, the filler metal will flow into and around the joint
- f) Always clean excess flux from joint

2. Correct any incorrect statements in the list above.

a) ______________________________

______________________________

b) ______________________________

______________________________

N. 1. What occurs when the base metal is not yet hot enough during braze welding?

______________________________

______________________________

2. What occurs when the base metal is too hot during brazing? ______________________________

______________________________

AIRFRAME
A204 AIRCRAFT WELDING
PERFORM BRAZING AND SOLDERING
A204-B

## WORKBOOK SUPPLEMENT #2 — Interpret Principles of Soldering

The aviation maintenance technician must utilize a metal joining process known as soldering when it is required. Soldering is used chiefly for copper, brass, and coated iron in combination with mechanical seams; where leakproof joints are required, for fitting joints to promote rigidity and prevent corrosion, and to join electrical connections. A thorough understanding of the tools, materials, and procedures will prove most beneficial in accomplishing the task of soldering.

Apply your knowledge of soldering by answering the following questions.

A. What are the three main purposes for using the soldering process in aircraft maintenance?

1. ____________________

2. ____________________

3. ____________________

B. 1. Why does scale form on the tip of a soldering copper? ____________________

2. Describe two methods used to clean a soldering copper.

a) ____________________

b) ____________________

## WORKBOOK SUPPLEMENT #2

C. Explain the following processes associated with soldering.

1. What is forging?

2. What is drawing?

3. What is filing?

4. What is tinning?

D. What is the difference between soldering and brazing?

## WORKBOOK SUPPLEMENT #2

E. 1. What is the weight/ratio of lead to tin in the two most common types of solder?

______________________________________________

2. Where is soft solder most often used? ______________________

3. What two forms does solder come in?

a) ______________________________________________

b) ______________________________________________

4. What must the aviation maintenance technician use in addition to solid wire solder when soldering?

______________________________________________

F. 1. What two types of materials can be found in hollow core solder?

a) ______________________________________________

b) ______________________________________________

2. Where is resin flux used?

______________________________________________

______________________________________________

G. 1. Select the true statements related to flame soldering from the list below. Circle the number before each true statement.

a) Flame soldering uses a torch to melt solder instead of melting it with a soldering copper

b) Flame soldering is used in easy-to-reach places where working with a copper would be impractical

c) Flame soldering is accomplished by adjusting the torch to a desired heat, then applying heat and solder to the spot being soldered

d) As soon as the solder starts to melt, keep the torch on the work so the metal will heat and then melt the tinning on the metal

2. Correct any incorrect statements in the list above.

a) ______________________________________________

______________________________________________

b) ______________________________________________

______________________________________________

## AIRFRAME
## A204 AIRCRAFT WELDING
## PERFORM BRAZING AND SOLDERING
## A204-B

## ANSWERS TO WORKBOOK SUPPLEMENTS

Workbook Supplement #1

A.
1. Oxidizing flame
2. Neutral flame
3. Solder or braze filler rod
4. Sal amoniac
5. Tinning
6. Flux
7. Carburizing flame
8. Oxidation
9. Capillary action
10. Scale
11. Resin core flux
12. Neutral flame

B. The student should answer with any three from the list below:

1. Cannot match the weld color to the color of the base metal
2. Cannot be used on metals and joints where stress is a factor
3. Will lose its strength at temperatures above 500°F
4. May have corrosion-resistant properties different from those of the base metal
5. Filler rod can be quite expensive

C. The answer should contain as many elements of the following paragraphs as possible:

1. In fusion welding, the filler rod has a melting point approximately the same as the base metal melting point, and both the filler metal and the base metal are melted and fused together.

2. In braze welding, the filler rod has a melting point below the melting point of the base metal, the base metal is never melted, and the weld is formed as a result of the brazing metal adhering to the base metal by molecular attraction and intergranular penetration; it does not fuse with the base metal

D. The answer should contain any four from the list below:

1. Braze welding is faster than fusion welding because the heat input required is less
2. Braze welding saves time and reduces fuel gas consumption
3. Braze welding minimizes preheating requirements
4. The reduction of heat input has special advantages for welding cast iron because the extremely ductile filler metal can absorb stresses as it cools
5. Due to a reduction in contraction and expansion, braze welding on steel reduces distortion of the base metal
6. Braze welding can be used to join dissimilar metals that cannot be fusion welded, such as copper to brass
7. When properly executed, braze welding steel or cast iron can produce a weld equal to or greater in strength than the original base metal

# ANSWERS TO WORKBOOK SUPPLEMENTS

E. 1. Brazing — In brazing, the filler metal must have a melting point above 800°F, but lower than the melting point of the base metal, and the filler metal is drawn into a tight-fitting joint by capillary attraction

2. Braze welding — In braze welding, the filler metal must have a melting point above 800°F, but lower than the melting point of the base metal, and the filler metal is deposited into the joint by gravity pull in the joint design, not by capillary attraction

F. The answer should contain any three of the following:

1. Chemically cleans the base metal
2. Prevents oxidation of the filler metal
3. Floats and removes the oxides already present
4. Increases the flow of the filler metal
5. Increases the ability of the filler metal to adhere to the base metal
6. Brings the filler metal into immediate contact with the metals being joined
7. Permits the filler metal to penetrate the pores of the base metal

G. 1. Tinning — The principle that brass and bronze; when raised to the proper temperature, will melt and form a smooth film (tinning) on the surface of a properly prepared and heated joint
2. Improper tinning action is almost always caused by overheating the base metal
3. Good tinning usually requires a neutral to slightly oxidizing flame

H. 1. a) Produce a high tensile strength
b) Increase ductility
2. Small quantities of tin, iron, manganese, and silicon

I. 1. Cleaning and preparation of the joint
2. Proper tinning of every bit of the joint achieved through cleaning action of the flux and proper metal temperature
3. Complete fusion between layers of filler metal when the weld is made in two or more passes

J. 1. a, c, d
2. a) When the base metal is no thicker than 1/8-inch to 3/16-inch, square edges may be used
b) Base metal should be cleaned at least 1/2-inch back from the edge of the joint whenever possible

K. 1. Oxides can be removed mechanically with a wire brush or a portable grinder
2. Oxides can be removed chemically with a suitable flux
3. Sometimes cleaning requires both methods

## ANSWERS TO WORKBOOK SUPPLEMENTS

L. 1. a, c, e, f
  2. a) Adjust torch to a slightly oxidizing flame
    b) As the base metal starts to glow dull red, heat the end of the filler rod and dip it in flux until it is well coated

M. 1. b, c, d, e, f
  2. Apply heat broadly, not in a pinpoint area

N. 1. The molten bronze forms into drops
  2. The molten bronze tends to bubble and boil

Workbook Supplement #2

A. 1. To provide reinforcement at points of stress where two pieces of metal are joined together
  2. To provide a waterproof joint where two pieces of metal are joined together
  3. To form a strong union between electrical wires that will have low electrical resistance

B. 1. Flux and impurities combine to form scale when the tip of the copper is not cleaned frequently
  2. a) A steel brush can be used to clean the residue off a copper tip each time it is removed from the furnace
    b) Dip the tip of the copper into a prepared solution of s[illegible]moniac and water while soldering

C. 1. This involves heating a copper in a furnace until the copper is cherry red, then filing off all the scale on the copper with a coarse file
  2. This involves placing the heated copper on an anvil and hammering the copper until it is drawn back to its original or near original shape
  3. This involves placing the copper in a vise and dressing the corners of the point with a fine file
  4. This involves heating the copper until it is cherry red, placing the tip on a block of sal amoniac, and adding small amounts of solder while rubbing the copper on the block of sal amoniac, then turning the copper until all sides are tinned

D. The difference between soldering and brazing is the temperature at which the filler materials melt. Solders all melt at temperatures below 800°F while brazing materials melt at temperatures above 800°F

# ANSWERS TO WORKBOOK SUPPLEMENTS

E. 1. 50-50 and 60-40
   2. Sheet metal and electrical work
   3. a) Bar
      b) Wire
   4. Flux or acid

F. 1. a) Resin flux
      b) Acid flux
   2. Copper lines and electronic/electrical applications

G. 1. a, c
   2. a) Flame soldering is used in hard-to-reach places where working with a copper would be impractical
      b) As soon as the solder starts to melt, pull the torch away from the work so the metal will not overheat and burn away the tinning on the metal

# AIRFRAME
# A204 AIRCRAFT WELDING
# PERFORM BRAZING AND SOLDERING
# A204-B

## PROJECT GUIDE #1 — Weld a Stringer Bead with a Bronze Rod on Steel Plate

PURPOSE: To allow you to develop skill in the construction of a bead formed by braze welding. You will continue to gain skill in using oxy-fuel welding equipment.

REFERENCE MANUALS:

A. EA-ITP-AB

B. AC 65-15A

EQUIPMENT AND TOOLS NEEDED:

A. Oxyacetylene welding unit with brazing tip

B. Welding goggles, safety glasses, and face shield

C. Welding gloves

D. Portable grinder

E. Vise

F. Pliers

G. Fire brick work table

H. Chipping hammer and wire brush

SUPPLIES AND MATERIALS:

A. Steel plate as selected by instructor

B. Bronze filler rod as selected by instructor

C. Flux as selected by instructor

PROCEDURE:

A. Check work area to assure that it is free of flammable materials and properly ventilated; note the location of the nearest fire extinguisher

B. Place selected metal in vise and grind surface to remove oxides

## PROJECT GUIDE #1

**WARNING**

**Always wear safety glasses and a face shield when grinding.**

C. Position metal flat on the firebrick work table

D. Select recommended brazing tip and put it on the torch finger-tight

E. Set up equipment and light torch according to safety procedures previously outlined in A204-B

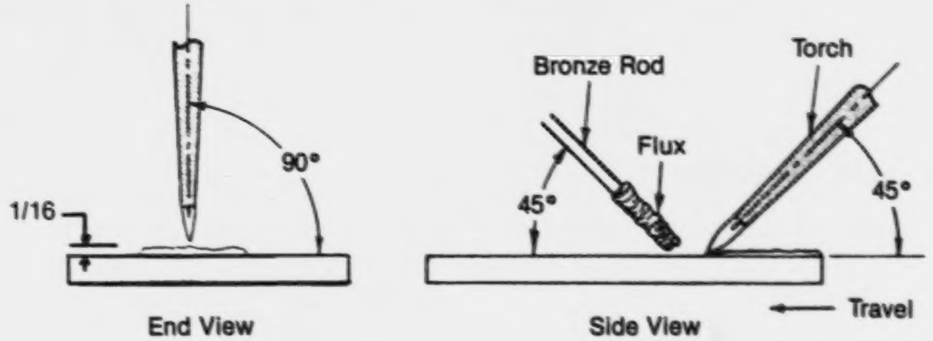
F. Adjust to slightly oxidizing flame

G. Place rod so that half of it extends over work table; hold the free end, then melt the rod in half to make it easier to handle and safer to work with

H. Heat rod slightly and dip in flux, if required

I. Hold the torch at approximately a 90° work angle and a 45° travel angle and move it down until flame is about 1/8" from the surface of the metal (Figure 1)

FIGURE 1



J. Heat an area of the base metal about 1/2" in diameter with a slightly circular torch motion until the metal is dull red

K. Insert the end of the rod into the area where the cone of the flame meets the plate immediately after the metal turns dull red

L. Allow a drop of molten bronze to form the beginning of the bead

M. Withdraw rod a short distance, move the flame forward in a slight circular motion, then reinsert the rod to allow more molten bronze to drop on the plate

N. Check the rod frequently to make sure it has flux on it; when the flux is gone, remove the rod and withdraw the flame slightly from the metal as you quickly dip the rod in the flux

## PROJECT GUIDE #1

O. Move flame back onto the metal and continue the procedures until the bead is completed

P. Stop just as you reach the end of the metal so molten bronze will not drip off the workpiece

Q. Shut torch off

R. Inspect bead for defects, especially consistent width, height, and uniform fusion with the base metal

(NOTE: When too much flux gets on the bead, it may require cleaning before inspection.)

S. Repeat the previous procedure until several parallel beads have been made across the sheet metal; be sure to stop, clean, and inspect as each bead is completed

T. Have your instructor check your work

U. Clean up area and put away tools and materials or prepare for next project guide as directed by your instructor

Material in this project guide adapted with permission of the Mid-America Vocational Curriculum Consortium, Stillwater, Oklahoma.

# AIRFRAME
# A204 AIRCRAFT WELDING
# PERFORM BRAZING AND SOLDERING
# A204-B

## PROJECT GUIDE #2 — Braze Weld a Butt Joint in Flat Position

PURPOSE: To allow you to gain skill in joining metals using the braze welding technique.

REFERENCE MANUALS:

A. EA-ITP-AB

B. AC 65-15A

EQUIPMENT AND TOOLS NEEDED:

A. Oxyacetylene welding unit with brazing tip

B. Welding goggles, safety glasses, and face shield

C. Welding gloves

D. Portable grinder

E. Vise

F. Pliers

G. Fire brick work table

H. Chipping hammer and wire brush

SUPPLIES AND MATERIALS:

A. Steel plates as selected by instructor

B. Bronze rod as selected by instructor

C. Flux as selected by instructor

PROCEDURE:

A. Check work area to assure that it is free of flammable materials and properly ventilated; note the location of the nearest fire extinguisher

B. Place selected pieces of metal in vise and grind surfaces and edges to remove oxides

**WARNING**

**Always wear safety glasses and a face shield when grinding.**

C. Position pieces of metal on the fire brick and align them about 1/16" apart for a butt joint

(NOTE: Do not lay the pieces of metal flat on the fire brick. Place other pieces of metal or fire bricks under them so there will be a space between the workpieces and the work table.)

D. Select recommended brazing tip and put it on the torch finger-tight

E. Set up equipment and light torch according to safety procedures previously outlined

F. Adjust to slightly oxidizing flame

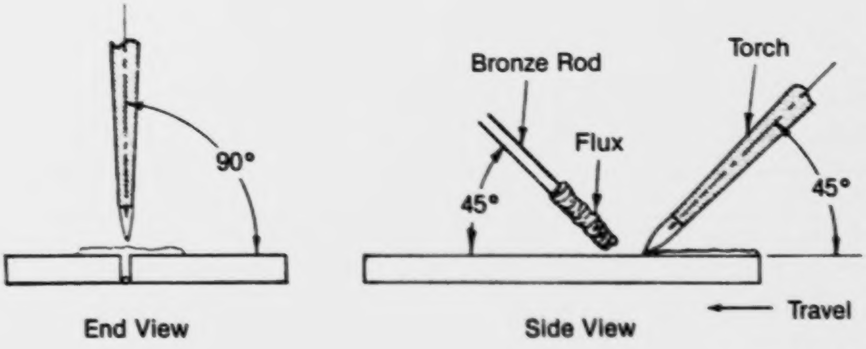
G. Place rod so that half of it extends over the work table; hold the free end, then melt the rod in half to make it easier to handle and safer to work with

H. Heat rod slightly and dip in flux, if required

I. Tack each end of the joint

J. Hold the torch at approximately a 90° work angle and a 45° travel angle and move down until the flame is about 1/8" from the surface of the metal (Figure 2)

FIGURE 2



End View

Side View

K. Heat about 1/8" of each edge of the joint with a slight circular motion of the torch until both edges are dull red

L. Position the flame in the center of the joint, then insert the rod into the cone of the flame

## PROJECT GUIDE #2

M. Allow a drop of molten bronze to fill the joint

N. Withdraw rod a short distance, move the flame forward in a slight circular motion, then reinsert the rod to allow more molten bronze to enter the joint

O. Check the rod frequently to make sure it has flux on it, and when the flux is gone, remove the rod, and withdraw the flame slightly from the joint as you quickly dip the rod in flux again

P. Move flame back into center of joint and continue procedure until the joint is completely brazed

Q. Stop just as you cover the tack weld so molten bronze will not drip off the end of the joint

R. Shut torch off

S. Inspect face of bead for defects, especially consistent width, height, and uniform fusion with the base metals

**WARNING**

**Never pick up a piece of hot metal even when wearing leather gloves. Always handle hot metal with a pair of pliers.**

U. Have your instructor check your work

V. Clean up area and put away tools and materials or prepare for next project guide as directed by your instructor

Material in this project guide adapted with permission of the Mid-America Vocational Curriculum Consortium, Stillwater, Oklahoma.

# AIRFRAME
# A204 AIRCRAFT WELDING
# PERFORM BRAZING AND SOLDERING
# A204-B

## PROJECT GUIDE #3 — Prepare a Soldering Iron Tip for Use

PURPOSE: To allow you to develop skill in preparing tools used in the soldering process.

REFERENCE MANUALS:

A. EA-ITP-AB

B. AC 65-15A

TOOLS AND EQUIPMENT NEEDED:

A. Soldering iron—pencil iron with copper or iron-bearing tip

B. Damp sponge

C. Fine wire brush

D. Fine metal file

E. Soldering iron holder

F. Safety goggles

SUPPLIES AND MATERIALS:

A. Tip cleaning flux if available (not necessary)

B. Tinning oil if available (not necessary)

C. 60/40 solder

PROCEDURE:

A. Put on safety goggles

B. Inspect the tip of the soldering iron while soldering iron is cool, and before connecting it to power receptacle

C. File the tip to a wedge shape without removing any more metal than is necessary

(NOTE: Copper tips can be reshaped with a metal file. Iron-bearing tips should not need reshaping. If you have an iron-bearing tip that is in poor shape, ask your instructor if it should be filed or replaced. Normally, iron-bearing tips are merely cleaned with a wire brush. Filing will shorten their useful life. Gold plated tips are used for particular applications and are expensive. Under normal conditions, gold-plated tips should never be filed or brushed. Cleaning is usually done with a damp sponge once the tip is hot. Special cleaning fluxes are used by industry for production line tips. However, if the shank of the tip is carboned or corroded, it can be brushed with the wire brush.)

D. Place soldering iron in holder and connect power cord to receptacle

E. Apply tinning oil to the hot tip

(NOTE: Do not put the tip into the oil container. Remove a small amount of tinning oil with a clean applicator or the tip of a clean screwdriver. Allow a drop to flow onto each surface of the hot tip's wedge.)

F. Apply 60/40 solder to the tip's wedged surfaces

**WARNING**

**Hot solder may drip from the tip. Allow it to drip onto the wet sponge. It can burn your skin or damage clothing.)**

G. Wipe excess solder from the tip on the wet sponge

H. Disconnect the soldering iron from the receptacle and place it in the holder to cool

I. After the iron has cooled, show it to your instructor

J. Clean up area and put away tools and materials or prepare for next project guide as directed by your instructor

AIRFRAME
A204 AIRCRAFT WELDING
PERFORM BRAZING AND SOLDERING
A204-B

## PROJECT GUIDE #4 — Solder Wire Splices

PURPOSE: To allow you to develop skill in reinforcing and producing low electrical resistance in electrical wire splices by soldering.

REFERENCE MANUALS:

A. EA-ITP-AB

B. AC 65-15A

EQUIPMENT AND TOOLS NEEDED:

A. Needle-nose pliers

B. Pliers with insulation stripping jaws and cutting jaws

C. Soldering tool—40 to 150 watt

D. Safety glasses

E. Bench vise

SUPPLIES AND MATERIALS:

A. 60/40 resin-core solder

B. Solid copper wire, 12 inches of AWG #12 or #14

PROCEDURE:

A. Put on safety goggles

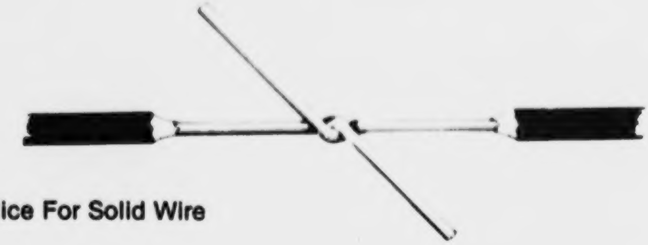
B. Cut three 3-inch lengths of the wire

C. Remove 1-inch lengths of insulation from the ends of each piece

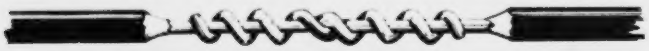
## PROJECT GUIDE #4

D. Construct splices shown in illustration below (Figure 3)

FIGURE 3



Simple Splice For Solid Wire



E. Lay splices neatly on the workbench and have your instructor inspect

F. Clamp the end of one splice in the bench vise

G. Heat the splice with the soldering tip

> **WARNING**
>
> **Soldering tools and splattering solder can produce serious burns. Return soldering tools to toolholders. Do not flip hot solder from soldering tool tips.)**

H. Place the solder on the splice, near, but not on the soldering tip

I. Allow solder to melt and flow into the splice

J. Remove the soldering iron and solder from the splice as soon as the solder fills the splice joint

(NOTE: Do not oversolder.)

K. Repeat procedures F through J for the other splices

L. Lay soldered splices on workbench and have your instructor inspect them

## PROJECT GUIDE #4

M. Disconnect soldering tool; allow to cool before putting it away

N. Return equipment and materials to their proper storage area

O. Clean shop area

AIRFRAME
A204 AIRCRAFT WELDING
PERFORM BRAZING AND SOLDERING
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## THEORY TEST

NAME ______________________________ SCORE ______________

1. Match the terms related to oxyacetylene braze welding, brazing, and soldering to their correct definitions. Write the correct numbers in the blanks.

_____a. A flame with more oxygen than a neutral flame

_____b. A translucent amber-colored to almost black brittle friable resin that is obtained by chemical means from the oleoresin or dead wood of pine trees or from tall oil and used in making soldering flux

_____c. A metal or metallic alloy used when melted to join metallic surfaces

_____d. The process of placing a thin film of filler metal along the joint of a preheated base metal

_____e. The chemical reaction of a metal with oxygen in the air, a process that promotes contamination of metal surfaces and eventually leads to rust

_____f. A white crystalline form of ammonium chloride used as a cleaning agent in soldering; available in block or powder form

_____g. A flame with a proportional amount of oxygen and acetylene whereby the burning oxidizes all particles of carbon and hydrogen in the acetylene

1. Resin core flux
2. Oxidation
3. Oxidizing flame
4. Sal amoniac
5. Solder or filler rod
6. Tinning
7. Neutral flame

## THEORY TEST

_____h. Contaminants that form in flaky configurations on the surface of a metal, usually the result of oxidation

_____i. The action by which the surface of a liquid, where it is in contact with a solid, is elevated or depressed depending on the relative attraction of the molecules of the liquid

_____j. A chemical in paste or powder form used to clean metals, protect from oxidation, and promote fusion in a welding process

_____k. A flame with more acetylene than a neutral flame

_____l. A chemical combination in which oxygen is combined with another element

8. Capillary action
9. Oxide
10. Scale
11. Carburizing flame
12. Flux

2. Braze welding and fusion welding can be identified by characteristics unique to both processes. Differentiate between these two processes. Write a "B" in the blanks before braze welding processes and an "F" in the blanks before fusion welding processes.

_____a. Filler metal and the base metal are both melted

_____b. Filler rod has a melting point below the melting point of base metal

_____c. Filler rod has approximately same melting point of base metal

_____d. Base metal is never melted

_____e. Joined by molecular attraction and intergranular penetration

3. Describe brazing and braze welding processes in a brief and accurate statement of each. Be sure that factors which allow the reader to differentiate between the two processes are included in your descriptions.

a. Brazing—________________________________________________

____________________________________________________________

____________________________________________________________

____________________________________________________________

b. Braze welding—______________________________________________

______________________________________________

______________________________________________

______________________________________________

4. Some of the following statements accurately describe the advantages of joining metals by braze welding. The rest of the statements are false. Select true statements concerning the advantages of braze welding and brazing. Write an "X" in the blanks before the correct answers.

_____a. Braze welding is faster than fusion welding because the heat input required is less

_____b. Braze welding saves time and reduces fuel gas consumption

_____c. Braze welding minimizes preheating requirements

_____d. The reduction of heat input has special advantages for welding cast iron because the extremely ductile filler metal can absorb stresses as it cools

_____e. Filler rods for braze welding cost less

_____f. Braze welding can be used to join dissimilar metals that cannot be fusion welded, such as copper to brass

_____g. Even when properly executed, braze welding can never produce a weld equal to the strength of the original base metal

_____h. Due to a reduction in contraction and expansion, braze welding on steel reduces distortion of the base metal

5. Select the true statments concerning the limitations of braze welding and brazing. Write an "X" in the blanks before the correct answers.

_____a. Cannot match the weld color to the color of the base metal

_____b. May have corrosion-resistant properties different from those of the base metal

_____c. Will lose its strength at temperatures above 200°F

_____d. Cannot be used on metals and joints where stress is a factor

# THEORY TEST

6. Explain the importance of tinning and how tinning is accomplished in braze welding and brazing by answering the following questions.

   a. What is the principle of tinning upon which brazing and braze welding processes are based? ______________________________

   ______________________________

   ______________________________

   ______________________________

   ______________________________

   b. What is the major requirement for proper tinning? ______________________________

   ______________________________

   ______________________________

   c. What type of flame usually produces good tinning? ______________________________

   ______________________________

   ______________________________

7. Select true statements concerning the purposes of flux. Write an "X" in the blanks before the correct answers.

   _____a. Chemically cleans the base metal

   _____b. Brings the filler metal into immediate contact with the metals being joined

   _____c. Prevents oxidation of the filler metal

   _____d. Decreases the flow of the filler metal

   _____e. Increases the ability of the filler metal to adhere to the base metal

   _____f. Floats and removes the oxides already present

   _____g. Permits the filler metal to penetrate the pores of the base metal

# THEORY TEST

8. Select true statements concerning the characteristics of filler rods for braze welding and brazing. Write an "X" in the blanks before the correct answers.

(NOTE: For a statement to be true, all parts of the statement must be true.)

_____a. Consists of copper alloys containing about 60 percent copper and 40 percent zinc which:

1) Produce a high tensile strength

2) Increase ductility

_____b. Require no cleaning before use

_____c. Contain small quantities of tin, iron, manganese, and silicon which help to:

1) Deoxidize the weld metal

2) Decrease the tendency to fume

3) Increase the free-flowing action of the molten metal

4) Increase the hardness of the deposited metal for greater wear resistance

9. There are numerous minor factors which contribute to the construction of a successful braze weld, but there are three most important factors common to all successful braze welds. State the three most important factors.

a. ______________________________

______________________________

b. ______________________________

______________________________

c. ______________________________

______________________________

10. Select true statements concerning joint preparation for braze welding. Write an "X" in the blanks before the correct answers.

_____a. Generally, joints for braze welding are prepared the same as for fusion welding for base metals of like thickness

_____b. In all cases, every part of the base metal to be tinned must be cleaned thoroughly until it is completely free of rust, scale, oil, and grease ______c. For metals thicker than 3/16-inch, beveled edges should be used

______d. Base metal should be cleaned at least 1/2-inch back from the edge of the joint whenever possible

______e. When the base metal is no thicker than 1/8-inch to 3/16-inch, square edges may be used

11. Briefly state the three methods used to remove oxides in joint preparation for braze welding or brazing.

a. ____________________________________________

____________________________________________

b. ____________________________________________

____________________________________________

c. ____________________________________________

____________________________________________

12. Select true statements concerning techniques for braze welding steel. Write an "X" in the blanks before the correct answers.

______a. Select a welding tip at least one size larger than would be selected for fusion welding a metal of equal thickness

______b. Adjust torch to a slightly oxidizing flame

______c. Move the flame back and forth over a small, pinpoint area of the base metal until it begins to glow dull red

______d. As the base metal starts to glow dull red, heat the end of the filler rod and dip it in flux until it is well coated

______e. As the base metal becomes dull red, move the rod into the flame until it comes in contact with and melts off onto the base metal

______f. When the melted bronze flows smoothly onto the surface of the base metal and flows evenly over a large area, the temperature is just right

13. Select true statements concerning techniques for brazing. Write an "X" in the blanks before the correct answers.

______a. Apply heat broadly, not in a pinpoint area

______b. Leave excess flux on brazed joint because it prevents corrosion _____c. Use a highly oxidizing flame for aluminum

_____d. Melt the filler rod with the heat of the torch; do not worry about the temperature of the base metal

_____e. Use enough flux to do the job, never less

14. Match brazing and braze welding problems to their correct causes. Write the correct numbers in the blanks.

| | |
|---|---|
| _____a. The molten bronze forms into drops | 1. Base metal is too hot |
| _____b. The molten bronze tends to bubble and boil | 2. Base metal is not yet hot enough |

(NOTE: Test questions 15-16 are project guides. They are an important part of this test. If they have not been completed, check with your instructor.)

15. Weld a stringer bead with a bronze rod on steel plate.

16. Braze weld a butt joint in flat position.

17. Differentiate between brazing and soldering. Write an "X" in the blank before the statement related to soldering.

_____a. This process uses a filler material which melts at temperatures below 800°F

_____b. This process uses a filler material which melts at temperatures above 800°F

18. List three purposes of soldering in aircraft maintenance.

a. ______________________________

______________________________

b. ______________________________

______________________________

c. ______________________________

______________________________

19. Discuss the guidelines for keeping soldering coppers clean by answering the following questions.

a. What is the result of not cleaning a soldering copper often enough?

______________________________

______________________________

b. What happens when scale accumulates on a copper? ______________________

______________________________________________

c. What can be used to clean a soldering copper if sal amoniac solution is not available? ______________________

______________________________________________

20. Match process names to processes used in maintaining soldering coppers. Write the correct numbers in the blanks.

_____a. This involves heating a copper in a furnace until the copper is cherry red, then filing off all the scale on the copper with a coarse file

_____b. This involves placing the heated copper on an anvil and hammering the copper until it is drawn back to its original or near original shape

_____c. This involves placing the copper in a vise and dressing the corners of the point with a fine file

_____d. This involves heating the copper until it is cherry red, placing the tip on a block of sal amoniac, and adding small amounts of solder while rubbing the copper on the block of sal amoniac, then turning the copper until all sides are tinned

1. Drawing
2. Filing
3. Forging
4. Tinning

21. Discuss characteristics of solder by answering the following questions.

a. How is solder classified? ______________________

______________________________________________

b. Where is soft solder used more frequently? ______________________

______________________________________________

c. Solder is available in what two forms? ______________________

______________________________________________

d. What two things may be found inside hollow wire solder? ______________________

______________________________________________

# THEORY TEST

22. Select true statements concerning soldering flux and its characteristics. Write an "X" in the blanks before the correct answers.

    (NOTE: For a statement to be true, all parts of the statement must be true.)

    _____a. Flux is either acid or resin

    1) Acid flux is noncorrosive

    2) Resin flux is corrosive

    _____b. Corrosive flux is used for many sheet metal applications, but must be cleaned immediately after the job is completed

    _____c. Noncorrosive resin flux is used for soldering copper water lines, automotive radiators, and in electronics where corrosive flux would be damaging

23. Select true statements concerning flame soldering and its technique. Write an "X" in the blanks before the correct answers.

    _____a. Flame soldering is used in hard-to-reach places where working with a copper would be impractical

    _____b. Flame soldering is accomplished by adjusting the torch to a desired heat, then applying heat and solder to the spot being soldered

    _____c. Flame soldering uses a torch to melt solder instead of melting it with a soldering copper

    _____d. As soon as the solder starts to melt, pull the torch away from the work so the metal will not overheat and burn away the tinning on the metal

(NOTE: Test questions 24 and 25 are project guides. They are an important part of this test. If they have not been completed, check with your instructor.)

24. Prepare a soldering iron tip for use.

25. Solder wire splices.

# AIRFRAME
## A204 AIRCRAFT WELDING
## PERFORM BRAZING AND SOLDERING
## A204-B

## ANSWERS TO THEORY TEST

1.
| | | | |
|---|---|---|---|
| a. | 3 | g. | 7 |
| b. | 1 | h. | 10 |
| c. | 5 | i. | 8 |
| d. | 6 | j. | 12 |
| e. | 2 | k. | 11 |
| f. | 4 | l. | 9 |

2. a. F
   b. B
   c. F
   d. B
   e. B

3. Description should include the following:

   a. In this procedure, the filler metal must have a melting point above 800°F, but lower than the melting point of the base metal, and the filler metal is drawn into a tight-fitting joint by capillary attraction
   b. In this procedure, the filler metal must have a melting point above 800°F, but lower than the melting point of the base metal, and the filler metal is deposited into the joint by gravity pull in the joint design, not by capillary attraction

4. a, b, c, d, f, h

5. a, b, d

6. a. Brass and bronze; when raised to the proper temperature, will melt and form a smooth film (tinning) on the surface of a properly prepared and heated joint
   b. A thoroughly clean and properly prepared joint
   c. Neutral to slightly oxidizing flame

7. a, b, c, e, f, g

8. a, c

## ANSWERS TO THEORY TEST

9. a. Cleaning and preparation of the joint
   b. Proper tinning of every bit of the joint achieved through cleaning action of the flux and proper metal temperature
   c. Complete fusion between layers of filler metal when the weld is made in two or more passes

10. a, b, c, d, e

11. a. Oxides can be removed mechanically with a wire brush or a portable grinder
    b. Oxides can be removed chemically with a suitable flux
    c. Sometimes cleaning requires both methods

12. a, b, d, e, f

13. a, e

14. a. 2
    b. 1

15. Performance skills evaluated to the satisfaction of the instructor

16. Performance skills evaluated to the satisfaction of the instructor

17. a

18. a. To provide reinforcement at points of stress where two pieces of metal are joined together
    b. To provide a waterproof joint where two pieces of metal are joined together
    c. To form a strong union between electrical wires that will have low electrical resistance

19. Discussion should include the following:

    a. Flux and impurities will form a scale on the tip of the copper
    b. It insulates the copper and prevents heat from transferring from the copper to the metal
    c. Steel brush

20. a. 3 c. 2
    b. 1 d. 4

## ANSWERS TO THEORY TEST

21. Discussion should include the following:

    a. By the weight ratio of tin to lead
    b. Sheet metal and electrical work
    c. Bar and wire
    d. Resin or acid flux

22. b, c

23. a, b, c, d

24. Performance skills evaluated to the satisfaction of the instructor

25. Performance skills evaluated to the satisfaction of the instructor

MODULE OF INSTRUCTION
FOR
AVIATION MAINTENANCE TECHNOLOGY

# AIRFRAME

## A204 AIRCRAFT WELDING

## PERFORM SHIELDED METAL ARC WELDING

## A204-C

# AIRFRAME
# A204 AIRCRAFT WELDING
# PERFORM SHIELDED METAL ARC WELDING
# A204-C

## MODULE CONTENTS

A. Introduction and Module Objective

B. Specific Objectives

C. Instructor's Module Implementation Guide

D. Technical Information Supplements

   1. Technical Information Supplement #1 — Terms and Definitions

   2. Technical Information Supplement #2 — Fundamentals of Shielded Metal Arc Welding

E. Transparency Masters

   1. TM #1 — Welding Circuit

   2. TM #2 — AWS Classification of Electrodes

   3. TM #3 — Types of Welds

   4. TM #4 — Parts of the Welding Process

F. Project Guides

   1. Project Guide #1 — Start, Stop, and Restart the Arc

   2. Project Guide #2 — Weld a Pad in the Flat Position

   3. Project Guide #3 — Weld a Square-Groove Butt Joint

G. Theory Test

H. Answers to Theory Test

# AIRFRAME
# A204 AIRCRAFT WELDING
# PERFORM SHIELDED METAL ARC WELDING
# A204-C

## INTRODUCTION

Electric arc welding is a fusion process based on the principle of generating heat with an electric arc jumping an air gap to complete an electrical circuit. This welding process is useful for joining some of the most common and most unusual metal alloys. The aviation maintenance technician uses arc welding to accomplish repairs necessary to maintain airworthy aircraft and also to perform normal maintenance in the hangar or shop. Along with being skilled at using the arc welding process for simple repairs, the technician must be highly skilled at evaluating a weld to determine its condition.

## MODULE OBJECTIVE

After completion of this module, you will be able to start, stop, and restart an arc, weld a pad in the flat position, and weld a square-groove butt joint. Your competency will be evaluated by completing project guides and by scoring a minimum of 85 percent on the module theory test.

# AIRFRAME
# A204 AIRCRAFT WELDING
# PERFORM SHIELDED METAL ARC WELDING
# A204-C

## SPECIFIC OBJECTIVES

After completion of this module, you will be able to:

| | |
|---|---|
| 1. Match terms related to shielded metal arc welding to their correct definitions. (1) | Technical Supplement #1 |
| 2. Name the types of arc welding machines. (1) | Technical Supplement #2 |
| 3. Name the common equipment needed in shielded metal arc welding. (1) | Technical Supplement #2 |
| 4. Distinguish between straight and reverse polarity. (2) | Technical Supplement #2 |
| 5. Select from a list the factors that determine the polarity to use in shielded metal arc welding. (1) | Technical Supplement #2 |
| 6. Name the two types of operating adjustments found on arc welding machines. (1) | Technical Supplement #2 |
| 7. Discuss in a short paragraph how to test for polarity. (2) | Technical Supplement #2 |
| 8. Name common types of electrodes. (1) | Technical Supplement #2 |
| 9. Name common sizes of electrodes. (1) | Technical Supplement #2 |
| 10. Select from a list the factor that identifies the electrode's size. (1) | Technical Supplement #2 |
| 11. Select from a list the purposes of flux coating on electrodes. (1) | Technical Supplement #2 |
| 12. Explain the meaning of the AWS electrode classification code. (2) | Technical Supplement #2 |
| 13. Name factors to consider when selecting an electrode for a specific job application. (1) | Technical Supplement #2 |
| 14. Name types of welds. (1) | Technical Supplement #2 |
| 15. Select from a list reasons for poor welds. (1) | Technical Supplement #2 |
| 16. Label the parts of the welding process. (1) | Technical Supplement #2 |

## SPECIFIC OBJECTIVES

| | | |
|---|---|---|
| 17. Name safety precautions to follow in shielded metal arc welding. (1) | Technical Supplement #2 | |
| 18. State the acceptable lens-shade numbers for shielded metal arc welding. (1) | Technical Supplement #2 | |
| 19. Discuss welding procedures and techniques used in shielded metal arc welding. (2) | AC 65-15A | 269-276 |
| 20. Start, stop, and restart the arc. (2) | Project Guide #1 | |
| 21. Weld a pad in the flat position. (2) | Project Guide #2 | |
| 22. Weld a square-groove butt joint. (2) | Project Guide #3 | |

# AIRFRAME
# A204 AIRCRAFT WELDING
# PERFORM SHIELDED METAL ARC WELDING
# A204-C

## INSTRUCTOR'S MODULE IMPLEMENTATION GUIDE

## I. Implementation Suggestions

(NOTE: Have students read all available resource material related to specific objectives.)

| Estimated Teaching Time | | Theory | Lab |
|---|---|---|---|
| Objective 1 | Using Technical Information Supplement #1, discuss the terms and definitions related to arc welding. Use examples, illustrations, and any other types of visuals to explain terms. | | |
| Objectives 2-3 | Use Technical Information Supplement #2 to discuss the four main types of arc welding machines. Point out the major differences in these machines. Display and name the common equipment used in shielded metal arc welding. | | |
| Objective 4 | Using Technical Information Supplement #2, describe how the SMAW machine is set up. Be sure to emphasize how the polarity of the process changes depending on whether the electrode is connected positive (+) or negative (–). Use Transparency Master #1. | | |
| Objective 5 | Using Technical Information Supplement #2, explain when a technician would use positive (+) polarity or negative (–) polarity. | | |
| Objective 6 | Using Technical Information Supplement #2, discuss the two types of operating adjustments found on arc welding machines. Show how the adjustments are made on the machines the students will be using. | | |
| Objective 7 | Use Technical Information Supplement #2 to describe how polarity can be determined in the shop. Demonstrate this procedure. | | |

## INSTRUCTOR'S MODULE IMPLEMENTATION GUIDE

| Estimated Teaching Time | | Theory | Lab |
|---|---|---|---|
| Objectives 8-9 | Discuss the most common types of electrodes and the most common sizes in which electrodes are available. Use Technical Information Supplement #2. | | |
| Objective 10 | Have examples of different types of electrodes for the class to examine. Explain how the size of an electrode is identified. Use Technical Information Supplement #2. | | |
| Objective 11 | State the purposes of flux coating on electrodes. Use Technical Information Supplement #2. | | |
| Objective 12 | Explain the AWS electrode classification code. Use Transparency Master #2 and Technical Information Supplement #2. | | |
| Objective 13 | Explain how a technician selects an electrode for a specific job application. Use Technical Information Supplement #2. | | |
| Objective 14 | Use Technical Information Supplement #2 to discuss the four different types of welds. Use Transparency Master #3. | | |
| Objective 15 | Explain the reasons for poor welds. Show examples of welds that have defects. Use Technical Information Supplement #2. | | |
| Objective 16 | Discuss the entire welding process using Transparency Master #4 and Technical Information Supplement #2. | | |
| Objective 17 | Discuss thoroughly all safety rules and precautions to be followed when performing shielded metal arc welding. Use Technical Information Supplement #2. | | |
| Objective 18 | Explain how to select the correct lens for arc welding and how to inspect the lens prior to use to determine its effectiveness. Use Technical Information Supplement #2. | | |

## INSTRUCTOR'S MODULE IMPLEMENTATION GUIDE

| Estimated Teaching Time | | Theory | Lab |
|---|---|---|---|
| Objective 19 | Discuss welding procedures and techniques related to SMAW. Have students read related material in AC 65-15A, and administer a quiz on material from theory lesson. | | |
| Objectives 20-22 | Discuss Project Guides #1, #2, and #3 with the class; review all pertinent safety rules and precautions, and demonstrate all procedures. Have the students complete the projects. Review the projects in class after all students have completed. | | |

# AIRFRAME
## A204 AIRCRAFT WELDING
## PERFORM SHIELDED METAL ARC WELDING
## A204-C

## TECHNICAL INFORMATION SUPPLEMENT #1 — Terms and Definitions

A. Shielded metal arc welding — Arc welding process wherein metals are united by heating with an electric arc between a coated metal electrode and the metal

B. Arc — Flow of electric current from the tip of the electrode to the base of the metal being welded

C. Electrode — Metal rod which conducts a current from the electrode holder to the base metal

D. Base metal — Metal to be welded or cut

E. Arc length — Distance from the end of the electrode to the point where the arc makes contact with work surface

F. Crater — Depression at the termination of a weld

G. Face of weld — Exposed surface of a weld, made by an arc or gas welding process, on the side from which welding was done

H. Flux — Fusible material or gas used to dissolve and/or prevent the formation of oxides, nitrides, or other undesirable inclusions formed in welding

I. Low-carbon steel — Steel containing 0.20 percent or less carbon

J. Pass — Single longitudinal progression of a welding operation along a joint or weld deposit

K. Porosity — Gas pockets or voids in metal

L. Spatter — Metal particles given off during welding which do not form a part of the weld

M. Tack weld — Weld made to hold parts in proper alignment until the final welds are made

(NOTE: This type of welding is for assembly purposes only.)

N. Puddle — Portion of a weld that is molten at the place the heat is supplied

O. Undercut — Groove melted into the base metal adjacent to the toe of the weld and left unfilled by weld metal

P. Weaving — Technique of depositing weld metal in which the electrode is oscillated

Q. Weld metal — Portion of a weld which has been melted during welding

## TECHNICAL INFORMATION SUPPLEMENT #1

R. Whipping — Inward and upward movement of the electrode which is employed in vertical welding to avoid undercut

S. AWS — American Welding Society

T. Disposition rate — Amount of filler metal deposited in any welding process; rated in pounds per hour

# AIRFRAME
# A204 AIRCRAFT WELDING
# PERFORM SHIELDED METAL ARC WELDING
# A204-C

## TECHNICAL INFORMATION SUPPLEMENT #2 — Fundamentals of Shielded Metal Arc Welding

A. Types of arc welding machines

1. AC (alternating current) transformer — Current alternating direction 120 times per second
2. AC-DC transformer rectifier — Provides either alternating current or direct current
3. Motor generator — Produces DC current
4. Engine generator — Produces DC current

B. Common equipment needed in shielded metal arc welding

1. Welding machine
2. Electrode holder with lead
3. Ground clamp with lead
4. Shield or helmet
5. Leather gloves
6. Chipping hammer
7. Safety goggles
8. Wire brush
9. Electrodes
10. Pliers
11. Protective clothing

C. Polarity

(NOTE: Welding leads must connect to correct terminals if machine has a polarity switch. Otherwise, a change in polarity is made by reversing leads on the terminals.)

1. Reverse — Current flows from base metal to electrode
2. Straight — Current flows from electrode to base metal

## TECHNICAL INFORMATION SUPPLEMENT #2

D. Factors that determine polarity

1. Electrode

   EXAMPLE: Commonly used electrodes and their polarity

   E-6010 DC (+) reverse polarity
   E-6012 AC-DC (−) straight polarity
   E-7018 AC-DC (+) reverse polarity
   E-7024 AC-DC (+) reverse or straight polarity

2. Type of flux on electrode

E. Machine operating adjustments

1. Current (amperage) settings

   (NOTE: More heat is produced when amps are increased. When amps are decreased, less heat is produced.)

2. Polarity

F. Testing for polarity

1. Weld a bead using E6010 reverse polarity electrode
   - a. Indication of straight polarity — Excessive amount of weld spatter and very erratic arc
   - b. Indication of reverse polarity — Smooth, quiet arc with minimum amount of weld spatter
2. Strike arc with carbon electrode
   - a. Indication of straight polarity — Smooth and quiet arc
   - b. Indication of reverse polarity — Carbon becomes extremely hot, pieces break off, black smudges appear on workpiece

G. Types of electrodes

1. Mild steel (See Table 1)
2. Low hydrogen—low alloy
3. Nonferrous
4. Hard surfacing
5. Cast iron

# TECHNICAL INFORMATION SUPPLEMENT #2

6. Stainless steel

**EXAMPLE:**

TABLE 1: Welding characteristics and operating data of mild steel electrodes

| | Coating Color | Position of Welding | Type of Current* Used | Penetration | Rate of Deposition | Appearance of Bead | Minimum Tensile Strength | 3/32" Size | 1/8" Size | 5/32" Size | 3/16" Size |
|---|---|---|---|---|---|---|---|---|---|---|---|
| E6010 | White | All Positions | DC, Reverse (+) | Deep | Av. Rate | Rippled and Flat | 62,000psi | | 75-130 | 90-175 | 140-225 |
| E6011 | White | All Positions | AC<br>DC, Reverse (+) | Deep | Av. Rate | Rippled and Flat | 62,000psi | | 75-120<br>70-110 | 90-160<br>80-145 | 120-200<br>110-180 |
| E6012 | Tan | All Positions | DC, Str.<br>AC (–) | Medium | Good Rate | Smooth and Convex | 67,000psi | 55-80<br>60-90 | 80-135<br>90-150 | 110-180<br>120-200 | 155-250<br>170-275 |
| E6013 | Dark Tan | All Positions | AC<br>DC, Str. (–) or Reverse | Mild | Good Rate | Smooth, Flat and Convex | 67,000psi | 65-100<br>60-90 | 90-140<br>80-125 | 140-200<br>125-180 | 200-260<br>180-235 |
| E7014 | Gray-Br. | All Positions | AC<br>DC, Str. (–) or Reverse | Medium | High Rate | Smooth, Flat and Convex | 70,000 | | 110-160<br>100-145 | 150-225<br>135-200 | 200-280<br>180-250 |
| E7016 | | All Positions | AC<br>DC, Reverse (+) | Mild to Medium | Good Rate | Smooth and Convex | 70,000<br>70,000 | 70-100<br>70-9100 | 80-130<br>80-130 | 120-170<br>120-170 | 170-250<br>170-250 |
| E7024 | Dark Gray | Flat<br>Hor. Fillets | AC, DC Straight or Reverse | Mild | Very High Rate | Smooth and Slightly Cvx. | 72,000 | 65-120<br>60-110 | 115-175<br>100-160 | 160-240<br>160-215 | 240-300<br>220-280 |
| E6027 | Red Brown | Flat<br>Hor. Fillets | Flat-DC, AC<br>Hor. Fillet DC Str. AC | Medium | Very High Rate | Flat to Concave | 62,000psi | | | 190-240<br>175-215 | 250-300<br>230-270 |
| E7018 | Gray | All Positions | AC<br>DC, Reverse (+) | Mild | High Rate | Smooth, Flat to Convex | 72,000 | 70-100<br>80-120 | 90-150<br>110-170 | 120-190<br>135-225 | 170-280<br>200-300 |
| E7028 | Gray-Br. | Flat<br>Hor. Fillets | AC<br>DC, Reverse (+) | Mild | Very High Rate | Smooth and Slightly Cvx | 72,000 | | | 180-270<br>170-240 | 240-330<br>210-300 |

*DC Reverse means DC, reverse polarity (electrode positive).
DC Straight means DC, straight polarity (electrode negative).

H. Common electrode sizes — 3/32", 1/8", 5/32", 3/16", 7/32", 1/4", 5/16"

(NOTE: Electrodes range in size from 1/16" to 5/16".)

I. Factor that identifies electrode's size—Diameter of bare end of electrode

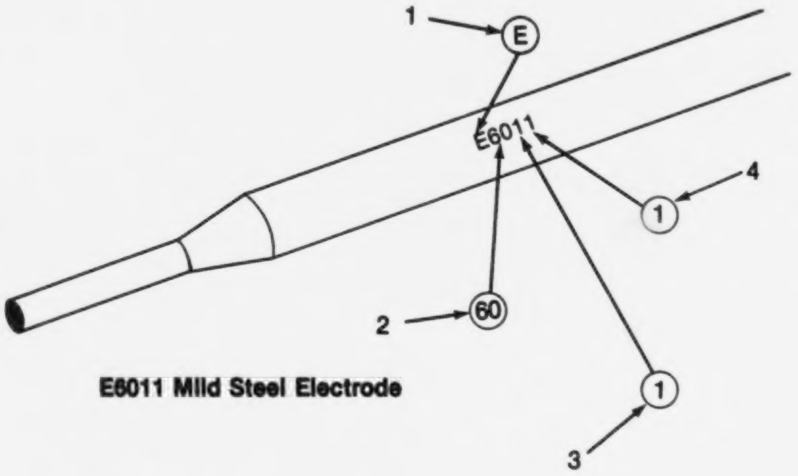
J. Purposes of flux coating

1. Stabilizes arc
2. Shields molten puddle from air
3. Floats impurities out of puddle

4. Forms slag and slows cooling
5. Provides deoxidizers and scavengers to prevent porosity of weld zone
6. Provides alloying elements for higher strength welds
7. Provides iron powder to increase the disposition rate

K. AWS electrode classification code (Figure 1)

FIGURE 1



E6011 Mild Steel Electrode

1. Letter E — Electric arc welding
2. First two numerals — Tensile strength deposited in thousand pounds per square inch
3. Third numeral — Welding position

   (NOTE: The welding position indicated may be all positions, flat and horizontal only, or flat only.)

4. Fourth numeral — Special characteristics and usability of rod

   (NOTE: The fourth numeral represents special characteristics such as polarity, penetration, type of welding machine, and type of flux.)

L. Factors to consider when selecting an electrode

1. Base metal strength properties
2. Base metal composition
3. Welding position

4. Welding current
5. Joint design and fit-up
6. Thickness and shape of base metal
7. Service conditions and/or specification
8. Production efficiency and job conditions

M. Types of welds

1. Bead
2. Fillet
3. Groove
4. Plug

N. Parts of groove and fillet welds

1. Groove weld
    a. Face
    b. Root
    c. Root face
    d. Root opening
    e. Groove face
    f. Groove angle
    g. Bevel angle
    h. Throat
2. Fillet weld
    a. Toe
    b. Face
    c. Throat
    d. Leg
    e. Root

## TECHNICAL INFORMATION SUPPLEMENT #2

O. Types of weld joints

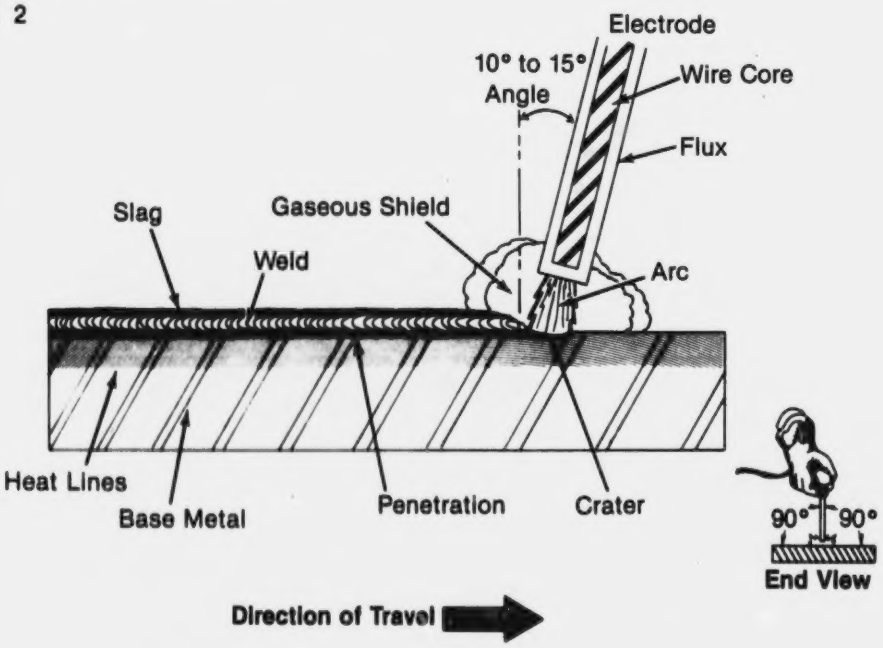
1. Butt
2. Corner
3. Tee
4. Lap
5. Edge

P. Reasons for poor welds

1. Improper machine adjustment
2. Improper size and type of electrode
3. Improper movement of electrode
4. Improper angle of electrode
5. Improper base metal preparation
6. Improper arc length

Q. Parts of welding process (Figure 2)

FIGURE 2


Electrode
10° to 15° Angle
Wire Core
Flux
Slag
Gaseous Shield
Weld
Arc
Heat Lines
Base Metal
Penetration
Crater
90°
90°
End View
Direction of Travel

## TECHNICAL INFORMATION SUPPLEMENT #2

R. Methods of striking arc

   1. Tapping

   2. Scratching

S. Safety precautions

   1. Keep equipment in good, clean, dry condition

   2. Make sure all electrical connections are tight, clean, and dry

   3. Use correct size welding cable—do not overload

   4. Be sure cables, holder, and connections are properly insulated

   5. Cut off power to welder before cleaning machine or making internal adjustments

   6. Never change polarity or current settings while machine is under load

   7. Observe normal operating care for electrical hazards

   8. Keep work area neat, clean, and dry

   9. Remove or shield flammable materials from welding area

   10. Do not weld near volatile, flammable liquids or gases

   11. Do not weld or cut on containers such as drums, barrels, or tanks until you know there is no danger of fire or explosion

   12. Dispose of hot electrode stubs in metal container

   13. Never strike arc on compressed gas cylinder

   14. Protect your eyes from rays of the arc; wear headshield with proper filter plates when welding or cutting

   15. Wear protective chipping goggles when chipping off weld slag

   (NOTE: Chip away from your face.)

   16. Wear leather gloves and protective clothing such as an apron, sleeves, etc. to shield against arc rays and sparks; button up shirt collar

   17. Use nonreflecting welding curtain to protect others in area from arc rays

   18. Be sure work area has adequate ventilation—plenty of fresh air

   (NOTE: Special precautions are necessary when welding lead, zinc, beryllium, copper, or cadmium.)

   19. Use pliers or tongs to handle hot metal; do not handle hot metal with bare hands or leather gloves

20. Always open main switch or disconnect plug when checking over welder

21. Do not leave electrode holder on welding table or in contact with grounded metal surface

22. Keep tools and metal in their proper locations

T. Acceptable lens-shade numbers for shielded metal arc welding—9 to 14 (Table 2)

(NOTE: The larger the lens-shade number, the darker the lens will be. Never look at an arc from any distance unless your eyes are protected by approved lenses.)

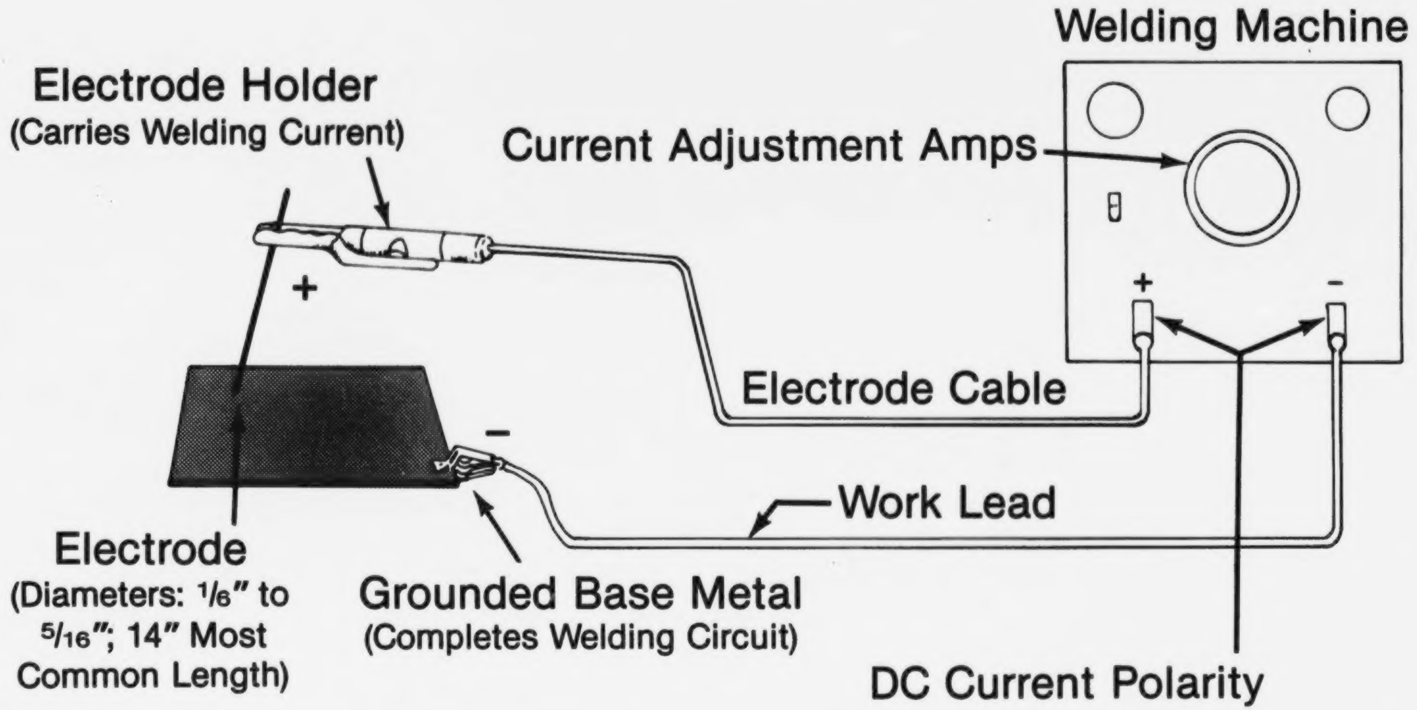
EXAMPLE:

TABLE 2: Lens-shade selector

| Type of operation | Shade number |
|---|---|
| Soldering | 2 |
| Torch brazing | 3 or 4 |
| Oxygen cutting | |
| Base-metal thickness | |
| 0 to 1 inch | 3 or 4 |
| 1 to 6 inches | 4 or 5 |
| 6 inches and over | 5 or 6 |
| Gas welding | |
| Base-metal thickness | |
| 0 to 1/8 inch | 4 or 5 |
| 1/8 to 1/2 inch | 5 or 6 |
| 1/2 inch and over | 6 or 8 |
| Shielded metal arc welding 1/16–, 3/32–, 1/8–, 5/32–inch electrodes | 9 to 14 |
| Gas metal arc welding | 9 to 14 |
| Gas tungsten arc welding (nonferrous), gas metal arc welding (nonferrous) 1/16–, 3/32–, 1/8–, 5/32–inch electrodes | 9 to 14 |
| Gas tungsten arc welding (ferrous), gas metal arc welding (ferrous) 1/16–, 3/32–, 1/8–, 5/32–inch, electrodes | 9 to 14 |

(NOTE: In oxyacetylene welding and cutting, lens-shade requirements are based on metal thickness, but in gas-shielded arc welding, lens-shade requirements are based on electrode size, the amperage range of the electrode, and base-metal properties.)

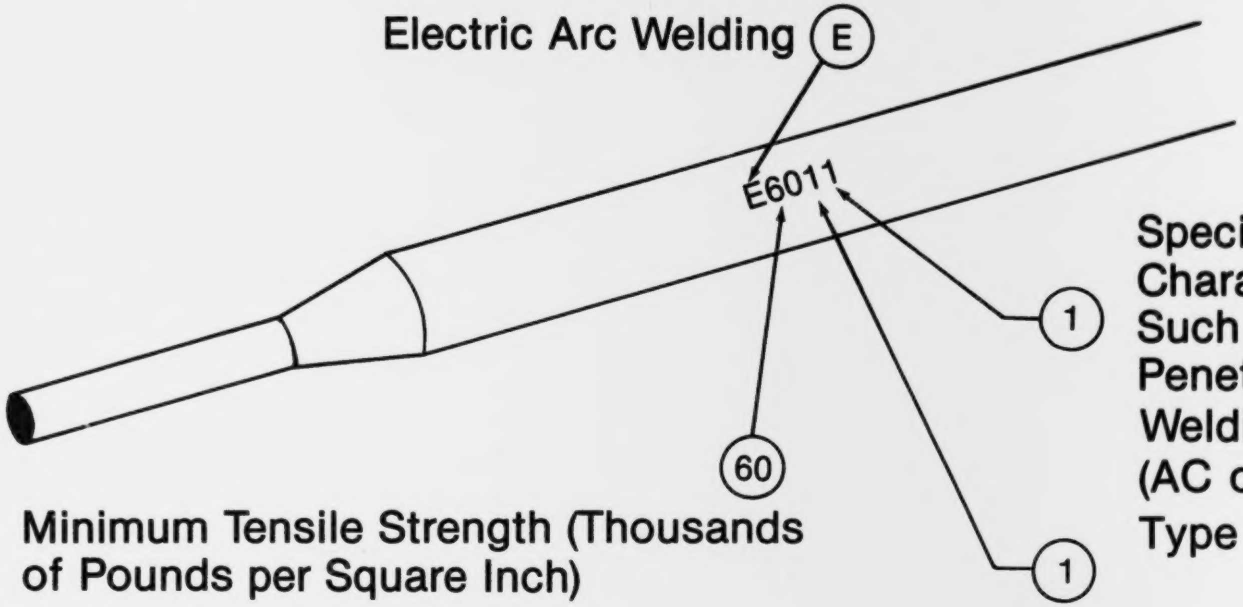
# Welding Circuit


Welding Machine
Electrode Holder
(Carries Welding Current)
Current Adjustment Amps
+
+
-
Electrode Cable
−
Work Lead
Electrode
(Diameters: 1/6" to 5/16"; 14" Most Common Length)
Grounded Base Metal
(Completes Welding Circuit)

## DC Current Polarity

| Reverse: | Straight: |
|---|---|
| 1. Electrode (+) | 1. Electrode (−) |
| 2. Current flows from base metal to electrode | 2. Current flows from electrode to base metal |
| 3. 2/3 heat at (+) electrode; 1/3 heat at (−) base metal | 3. 2/3 heat at (−) base metal; 1/3 heat at (+) electrode |

# AWS Classification of Electrodes



Electric Arc Welding

Special Characteristics Such as Polarity, Penetration, Type of Welding Machine (AC or DC), and Type of Flux

Minimum Tensile Strength (Thousands of Pounds per Square Inch)

Welding Position

1--All Positions

2--Flat and Horizontal Only

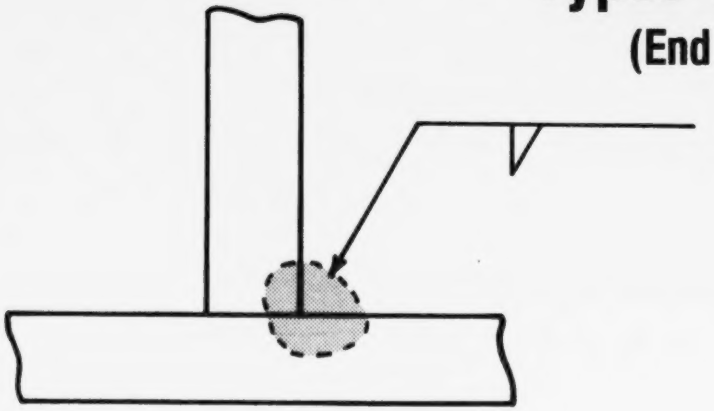
3--Flat Only

**E6011 Mild Steel Electrode**

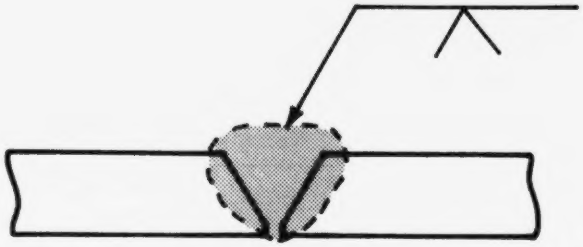
A204C-23

# Types of Welds

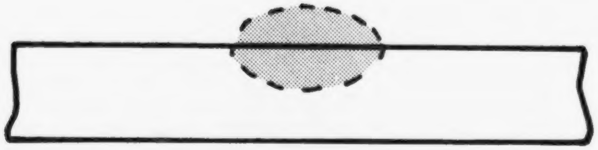
(End Views)



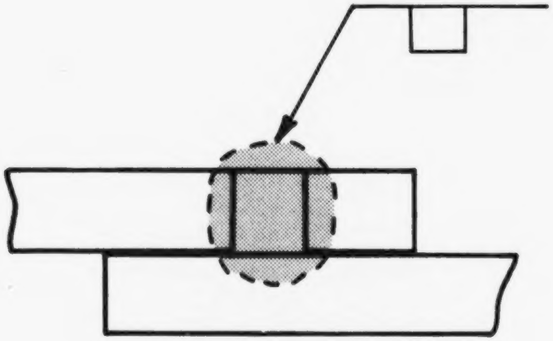
Fillet



Groove



Bead

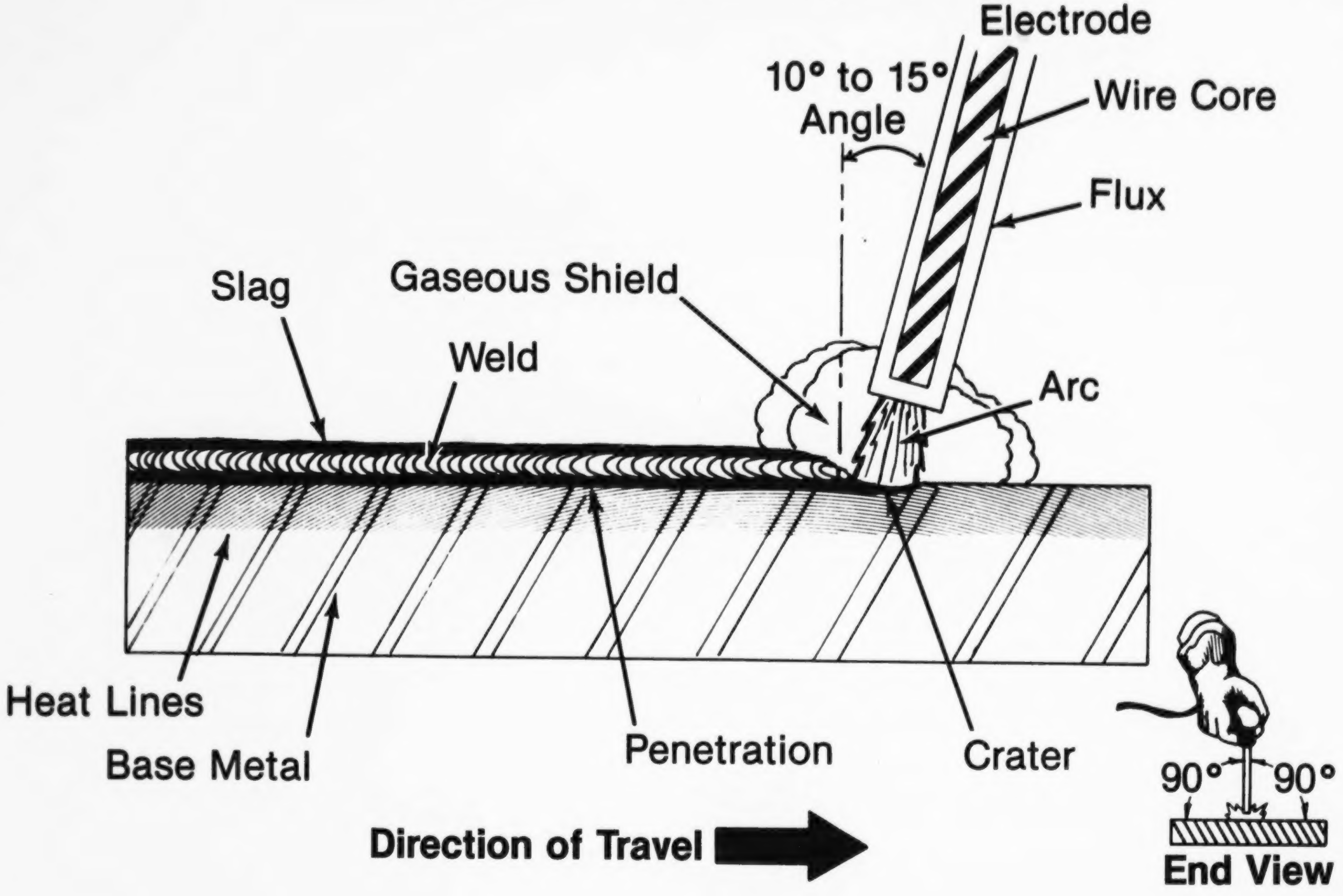


Plug

A204C-25

TM #3

# Parts of the Welding Process


Electrode
10° to 15° Angle
Wire Core
Flux
Slag
Gaseous Shield
Weld
Arc
Heat Lines
Base Metal
Penetration
Crater
90°
90°
End View
Direction of Travel

A204C-27

TM #4

# AIRFRAME
# A204 AIRCRAFT WELDING
# PERFORM SHIELDED METAL ARC WELDING
# A204-C

## PROJECT GUIDE #1 — Start, Stop, and Restart the Arc

PURPOSE: To develop competency in the skills of starting, stopping, and restarting an arc in shielded metal arc welding.

REFERENCE MANUAL: Welding machine manufacturer's manual

EQUIPMENT AND TOOLS:

A. Welding machine and accessories

B. Welding helmet

C. Safety glasses or goggles

D. Protective clothing

E. Leather gloves

SUPPLIES AND MATERIALS:

A. 4" × 4" mild steel plate, 1/4 inch to 3/8 inch thick

B. 1/8-inch or 5/32-inch E6010 electrode

PROCEDURE:

(NOTE: Safety glasses or goggles should be worn in the shop at all times.)

A. Set up welding machine, and prepare work area as directed by instructor

B. Start bead

1. Adjust machine to desired welding current

   (NOTE: The desired current will depend on type and size of electrode and thickness of metal. However, always refer to manufacturer's manual, when possible, for specific welding machine adjustments.)

2. Put on welding helmet and leather gloves

3. Hold electrode perpendicular to work where weld is to start

4. Slant electrode 10 to 15 degrees in direction of travel

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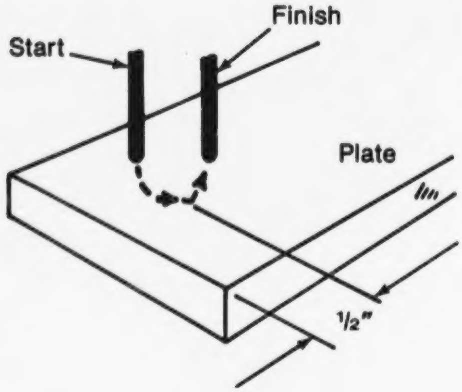
5. Lower electrode and tap or scratch lightly on edge of plate to strike arc (Figure 3)

FIGURE 3



6. Momentarily raise electrode upon establishment of arc to preheat edge of metal

7. Lower electrode to correct arc length

   (NOTE: Arc length is correct when it makes a "frying" noise. The force of the arc determines penetration and bead appearance.)

8. Rotate electrode to obtain desired height and width of bead

9. When crater develops, move electrode out slowly using normal manipulation

C. Stop bead

1. Return electrode to position perpendicular to work

2. Reverse direction of electrode movement, and hold until crater fills

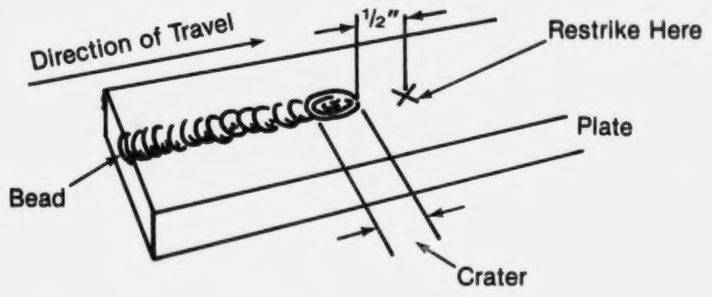
   (NOTE: This causes crater build-up, removes impurities from weld, and prevents crater from cracking.)

3. Raise electrode quickly when desired width and height of bead are obtained

D. Restart bead

1. Start arc about 1/2 inch to 3/4 inch in front of crater (See Figure 4)

FIGURE 4


Direction of Travel
1/2"
Restrike Here
Plate
Bead
Crater

2. With long arc, move electrode back to within $^1/_{16}$ inch of crater crown, fill to bead size, then resume normal travel

3. Fuse new crater into last ripple of crater

4. Move electrode out of crater when weld bead is established, and stop the arc

E. Shut down equipment

F. Check in tools and equipment, or prepare for next project as directed by instructor

# AIRFRAME
# A204 AIRCRAFT WELDING
# PERFORM SHIELDED METAL ARC WELDING
# A204-C

## PROJECT GUIDE #2 — Weld a Pad in the Flat Position

PURPOSE: To develop competency in welding a pad in the flat position using shielded metal arc welding.

REFERENCE MANUAL: Welding machine manufacturer's manual

EQUIPMENT AND TOOLS:

A. Welding machine and accessories

B. Welding helmet

C. Safety glasses or goggles

D. Protective clothing

E. Leather gloves

F. Chipping hammer

G. Wire brush

H. Pliers or vise grips

SUPPLIES AND MATERIALS:

A. 6" × 6" mild steel plate, 3/8 inch thick

B. 1/8-inch or 5/32-inch E6010 electrodes

PROCEDURE:

(NOTE: Safety glasses or goggles should be worn in the shop at all times.)

A. Set up welding machine, and prepare work area as directed by instructor

B. Adjust welding machine to desired current

(NOTE: The desired current will depend on type and size of electrode and thickness of metal. However, always refer to manufacturer's manual, when possible, for specific welding machine adjustments.)

C. Prepare metal for welding by removing dirt, grease, or mill scale

D. Place metal in flat position

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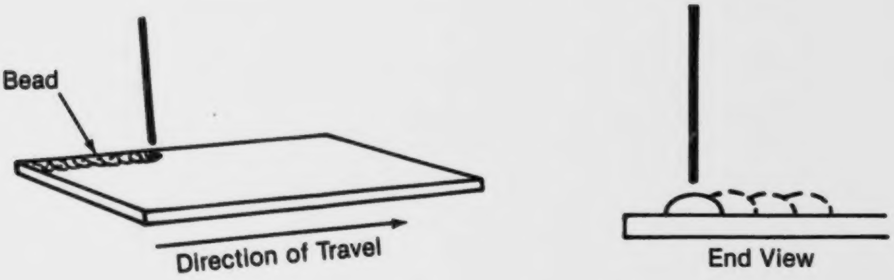
E. Put on welding helmet and leather gloves

F. Run a straight bead near edge of plate, holding electrode vertically with no side angle (Figure 5)

(NOTE: Avoid burning off edge of plate.)

FIGURE 5


Bead
Direction of Travel
End View

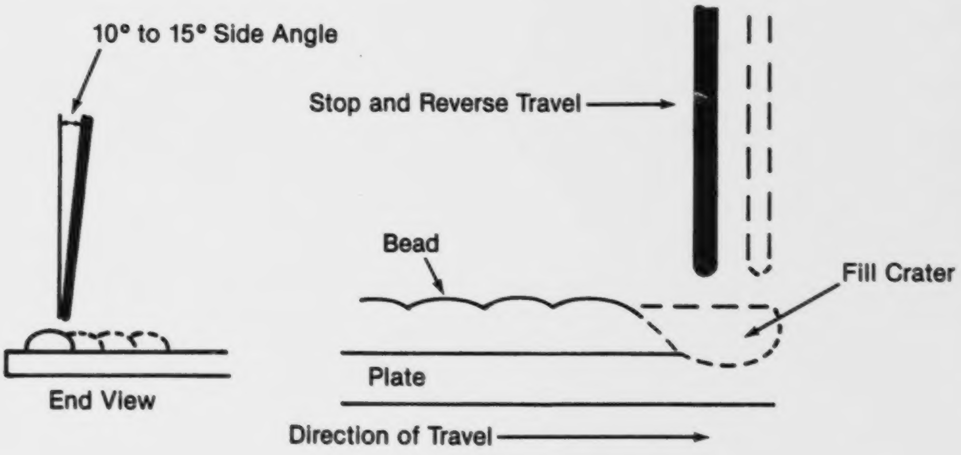
G. Clean bead with chipping hammer and wire brush, and check surface

(NOTE: The surface appearance should be smooth and even. Check for pinholes, crater holes, slag holes, or indications of improper starts and stops. Also, checking the bead will identify if current needs to be changed.)

H. Run additional beads

1. Reverse direction of travel, and hold electrode at a 10- to 15-degree angle to side (Figure 6)

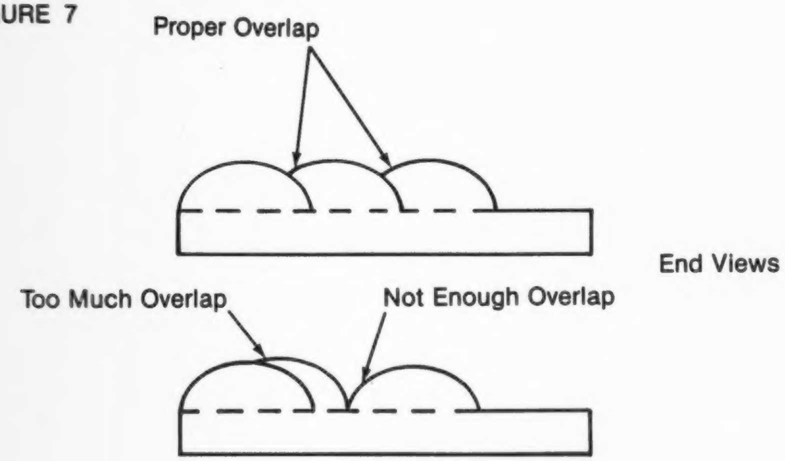
FIGURE 6


10° to 15° Side Angle
Stop and Reverse Travel
Bead
Fill Crater
End View
Plate
Direction of Travel

2. Fuse pass with base metal and previous bead, overlapping one-third of previous bead (Figure 7)

   (NOTE: The overlapping beads should produce a comparatively smooth surface without noticeable valleys between passes. Excessive overlap makes the bead too high crowned. Not enough overlap makes a V-shaped depression, and slag may be trapped in this area.)

FIGURE 7



3. Clean pass thoroughly before running next bead

   (NOTE: This will ensure a sound deposit with proper penetration and no slag holes.)

I. Continue running beads, alternating direction of travel for each pass, until pad is full

J. Shut down equipment

K. Clean pad thoroughly, and turn in to instructor for evaluation

L. Check in tools and equipment, or prepare for next project as directed by instructor

# AIRFRAME
# A204 AIRCRAFT WELDING
# PERFORM SHIELDED METAL ARC WELDING
# A204-C

## PROJECT GUIDE #3 — Weld a Square-Groove Butt Joint

PURPOSE: To develop competency in welding a square-groove butt joint using shielded metal arc welding.

REFERENCE MANUAL: Welding machine manufacturer's manual

EQUIPMENT AND TOOLS:

A. Welding machine and accessories

B. Welding helmet

C. Protective clothing

D. Leather gloves

E. Chipping hammer

F. Wire brush

G. Safety glasses or goggles

SUPPLIES AND MATERIALS:

A. Two 2" × 6" mild steel plates, 3/16 inch to 1/4 inch thick

B. 1/8-inch or 5/32-inch E6010 electrodes

PROCEDURE:

(NOTE: Safety glasses or goggles should be worn in the shop at all times.)

A. Adjust welding machine to correct welding current

(NOTE: The desired current will depend on type and size of electrode and thickness of metal. However, always refer to the manufacturer's manual, when possible, for specific welding machine adjustments.)

B. Prepare metal for welding by removing dirt, grease, or mill scale

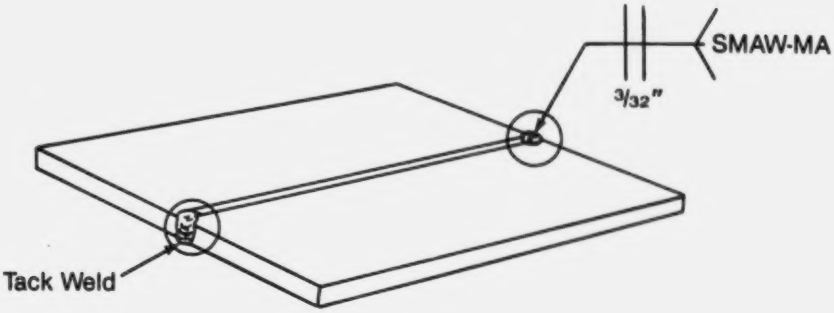
C. Place metal pieces parallel to each other, leaving a 3/32-inch space between them

(NOTE: The proper space can be determined by placing the bare end of a 3/32-inch electrode between the two pieces of metal.)

D. Put on welding helmet

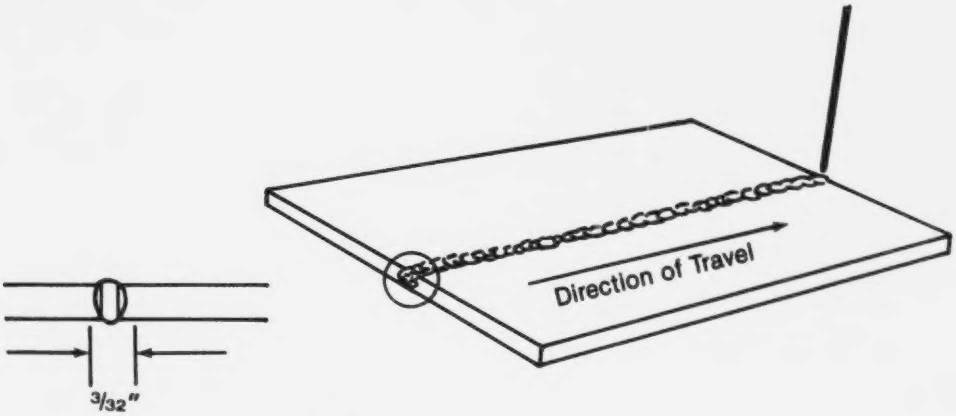
E. Tack weld pieces together at both ends (Figure 8)

FIGURE 8



F. Weld pieces together using single pass on one side for 100 percent penetration (Figure 9)

FIGURE 9



G. Shut down equipment

H. Chip slag, brush weld, and check for complete penetration at the root of weld

I. Turn in completed weld to instructor for evaluation

J. Clean work area, and return tools and equipment to proper storage area

## AIRFRAME
## A204 AIRCRAFT WELDING
## PERFORM SHIELDED METAL ARC WELDING
## A204-C

### THEORY TEST

1. Match terms related to shielded metal arc welding to their correct definitions. Write the correct numbers in the blanks.

_____a. Exposed surface of a weld, made by an arc or gas welding process, on the side from which welding was done

_____b. Arc welding process wherein metals are united by heating with an electric arc between a coated metal electrode and the metal

_____c. Depression at the termination of a weld

_____d. Flow of electric current from the tip of the electrode to the base of the metal being welded

_____e. Distance from the end of the electrode to the point where the arc makes contact with work surface

_____f. Metal rod which conducts a current from the electrode holder to the base metal

_____g. Metal to be welded or cut

_____h. Fusible material or gas used to dissolve and/or prevent the formation of oxides, nitrides, or other undesirable inclusions formed in welding

_____i. Portion of weld that is molten at the place the heat is supplied

_____j. Weld made to hold parts in proper alignment until the final welds are made

_____k. Steel containing 0.20 percent or less carbon

_____l. Metal particles given off during welding which do not form a part of the weld

_____m. Single longitudinal progression of a welding operation along a joint or weld deposit

_____n. Gas pockets or voids in metal

1. Shielded metal arc welding
2. Porosity
3. Electrode
4. Base metal
5. Spatter
6. Arc length
7. Tack weld
8. Crater
9. Face of weld
10. Flux
11. Low-carbon steel
12. Pass
13. Puddle
14. Arc

## THEORY TEST

______ o. Inward and upward movement of the electrode which is employed in vertical welding to avoid undercut

______ p. Groove melted into the base metal adjacent to the toe of the weld and left unfilled by weld metal

______ q. Portion of a weld which has been melted during welding

______ r. Technique of depositing weld metal in which the electrode is oscillated

______ s. American Welding Society

______ t. Amount of filler metal deposited in any welding process; rated in pounds per hour

15. AWS
16. Weld metal
17. Undercut
18. Disposition rate
19. Weaving
20. Whipping

2. Name the types of arc welding machines.

a. ______________________________

b. ______________________________

c. ______________________________

d. ______________________________

3. Name the common equipment needed in shielded metal arc welding.

a. ______________________________

b. ______________________________

c. ______________________________

d. ______________________________

e. ______________________________

f. ______________________________

g. ______________________________

h. ______________________________

i. ______________________________

j. ______________________________

k. ______________________________

4. Distinguish between straight and reverse polarity. Write an "X" in the blank before the statement that signifies reverse polarity.

______ a. Current flows from electrode to base metal

______ b. Current flows from base metal to electrode

## THEORY TEST

5. Select from the following list the factors that determine the polarity to use in shielded metal arc welding. Write an "X" in the blanks before the correct answers.

   _____a. Type of flux on electrode

   _____b. Electrode

   _____c. Current

   _____d. Brand of welding machine

6. Name the two types of operating adjustments found on arc welding machines.

   a. ______________________________________________

   b. ______________________________________________

7. Discuss in a short paragraph how to test for polarity.

   ______________________________________________

   ______________________________________________

   ______________________________________________

   ______________________________________________

   ______________________________________________

   ______________________________________________

   ______________________________________________

   ______________________________________________

   ______________________________________________

   ______________________________________________

   ______________________________________________

   ______________________________________________

8. Name four common types of electrodes.

   a. ______________________________________________

   b. ______________________________________________

   c. ______________________________________________

   d. ______________________________________________

## THEORY TEST

9. Name four common sizes of electrodes.

a. ______________________________

b. ______________________________

c. ______________________________

d. ______________________________

10. Select from the following list the factor that identifies the electrode's size. Write an "X" in the blank before the correct answer.

______a. Length of electrode

______b. Diameter of bare end of electrode

______c. Type of flux on electrode

11. Select from the following list the purposes of flux coating on electrodes. Write an "X" in the blanks before the correct answers.

______a. Stabilizes arc

______b. Makes arc starting difficult

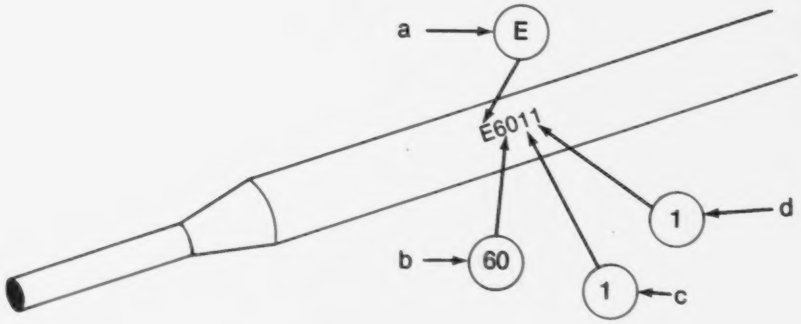
______c. Shields molten puddle from air

______d. Provides deoxidizers and scavengers to prevent porosity of weld zone

______e. Keeps moisture out of filler metal

______f. Forms slag and slows cooling

12. Explain the meaning of the AWS electrode classification code. Write the correct answers in the blanks.



a. ______________________________

b. ____________________

c. ____________________

d. ____________________

13. Name five factors to consider when selecting an electrode for a specific job application.

a. ____________________

b. ____________________

c. ____________________

d. ____________________

e. ____________________

14. Name types of welds.

a. ____________________

b. ____________________

c. ____________________

d. ____________________

15. Select from the following list reasons for poor welds. Write an "X" in the blanks before the correct answers.

______a. Improper angle of electrode

______b. Improper size and type of electrode

______c. Improper machine adjustment

______d. Improper clamping of electrode in holder

______e. Welding from left to right with the forehand technique

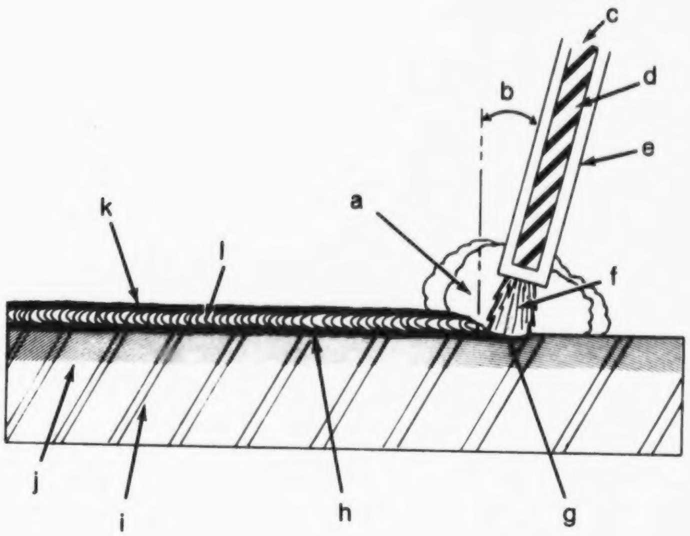
______f. Improper base metal preparation

______g. Running a E6010 electrode on DCRP

______h. Improper arc length

## THEORY TEST

16. Label the parts of the welding process illustrated below. Write the correct answers in the blanks.



a. ____________________

b. ____________________

c. ____________________

d. ____________________

e. ____________________

f. ____________________

g. ____________________

h. ____________________

i. ____________________

j. ____________________

k. ____________________

l. ____________________

## THEORY TEST

17. Name five safety precautions to follow in shielded metal arc welding.

    a.

    b.

    c.

    d.

    e.

18. State the acceptable lens-shade numbers for shielded metal arc welding.

19. Discuss welding procedures and techniques used in shielded metal arc welding by answering the following questions.

    a. What is the result of poor ground connection?

    b. What is the result of advancing the electrode too quickly when forming a stringer bead on a plate?

    c. When using the multiple-pass welding technique, what determines the sequence of the beads?

d. The proper angle of inclination range for the electrode when welding in a straight line at a constant speed is how many degrees?

_______________________________________________

(NOTE: Test questions 20-22 are project guides. They are an important part of this test. If they have not been completed, check with your instructor.)

20. Start, stop, and restart the arc.

21. Weld a pad in the flat position.

22. Weld a square-groove butt joint.

# AIRFRAME
# A204 AIRCRAFT WELDING
# PERFORM SHIELDED METAL ARC WELDING
# A204-C

## ANSWERS TO THEORY TEST

1. a. 9
   b. 1
   c. 8
   d. 14
   e. 6
   f. 3
   g. 4
   h. 10
   i. 13
   j. 7
   k. 11
   l. 5
   m. 12
   n. 2
   o. 20
   p. 17
   q. 16
   r. 19
   s. 15
   t. 18

2. a. AC (alternating current) transformer
   b. AC-DC transformer rectifier
   c. Motor generator
   d. Engine generator

3. a. Welding machine
   b. Electrode holder with lead
   c. Ground clamp with lead
   d. Shield or helmet
   e. Leather gloves
   f. Chipping hammer
   g. Safety goggles
   h. Wire brush
   i. Electrodes
   j. Pliers
   k. Protective clothing

4. b

5. a, b

6. a. Current (amperage) settings
   b. Polarity

7. Discussion should include the following

   a. Weld a bead using E6010 reverse polarity electrode
      1) Indication of straight polarity — Excessive amount of weld spatter and very erratic arc
      2) Indication of reverse polarity — Smooth, quiet arc with minimum amount of weld spatter

   b. Strike arc with carbon electrode
      1) Indication of straight polarity — Smooth and quiet arc
      2) Indication of reverse polarity — Carbon becomes extremely hot, pieces break off, black smudges appear on workpiece

## ANSWERS TO THEORY TEST

8. Answer should include any four of the following

   a. Mild steel
   b. Low hydrogen—low alloy
   c. Nonferrous
   d. Hard surfacing
   e. Cast iron
   f. Stainless steel

9. Answer should include any four of the following

   a. 3/32"
   b. 1/8"
   c. 5/32"
   d. 3/16"
   e. 7/32"
   f. 1/4"
   g. 5/16"

10. b

11. a, c, d, f

12. a. Electric arc welding
    b. Tensile strength deposited in thousand pounds per square inch
    c. Welding position
    d. Special characteristics and usability of rod

13. Answer should include any five of the following

    a. Base metal strength properties
    b. Base metal composition
    c. Welding position
    d. Welding current
    e. Joint design and fit-up
    f. Thickness and shape of base metal
    g. Service conditions and/or specification
    h. Production efficiency and job conditions

14. a. Bead
    b. Fillet
    c. Groove
    d. Plug

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## ANSWERS TO THEORY TEST

15. a, b, c, f, h

16. a. Gaseous shield
    b. 10° to 15° angle
    c. Electrode
    d. Wire core
    e. Flux
    f. Arc
    g. Crater
    h. Penetration
    i. Base metal
    j. Heat lines
    k. Slag
    l. Weld

17. Answer should include any five of the following

    a. Keep equipment in good, clean, dry condition
    b. Make sure all electrical connections are tight, clean, and dry
    c. Use correct size welding cable—do not overload
    d. Be sure cables, holder, and connections are properly insulated
    e. Cut off power to welder before cleaning machine or making internal adjustments
    f. Never change polarity or current settings while machine is under load
    g. Observe normal operating care for electrical hazards
    h. Keep work area neat, clean, and dry
    i. Remove or shield flammable materials from welding area
    j. Do not weld near volatile, flammable liquids or gases
    k. Do not weld or cut on containers such as drums, barrels, or tanks until you know there is no danger of fire or explosion
    l. Dispose of hot electrode stubs in metal container
    m. Never strike arc on compressed gas cylinder
    n. Protect your eyes from rays of the arc; wear headshield with proper filter plates when welding or cutting
    o. Wear protective chipping goggles when chipping off weld slag
    p. Wear leather gloves and protective clothing such as an apron, sleeves, etc. to shield against arc rays and sparks; button up shirt collar
    q. Use nonreflecting welding curtain to protect others in area from arc rays
    r. Be sure work area has adequate ventilation—plenty of fresh air
    s. Use pliers or tongs to handle hot metal; do not handle hot metal with bare hands or leather gloves
    t. Always open main switch or disconnect plug when checking over welder
    u. Do not leave electrode holder on welding table or in contact with grounded metal surface
    v. Keep tools and metal in their proper locations

## ANSWERS TO THEORY TEST

18. 9 to 14

19. a. A fluctuating, difficult-to-control arc
    b. The bead will be too narrow and have little or no fusion at the plate
    c. The kind of joint and the position of the metal
    d. 10 to 15 degrees

20. Performance skills evaluated to the satisfaction of the instructor

21. Performance skills evaluated to the satisfaction of the instructor

22. Performance skills evaluated to the satisfaction of the instructor

MODULE OF INSTRUCTION
FOR
AVIATION MAINTENANCE TECHNOLOGY

# AIRFRAME

## A204 AIRCRAFT WELDING

## PERFORM GAS TUNGSTEN ARC WELDING

## A204-D

## AIRFRAME
## A204 AIRCRAFT WELDING
## PERFORM GAS TUNGSTEN ARC WELDING
## A204-D

### MODULE CONTENTS

A. Introduction and Module Objective

B. Specific Objectives

C. Instructor's Module Implementation Guide

D. Technical Information Supplements

  1. Technical Information Supplement #1 — Terms and Definitions
  2. Technical Information Supplement #2 — Fundamentals of Gas Tungsten Arc Welding

E. Transparency Masters

  1. TM #1 — GTAW Welding Machine
  2. TM #2 — GTAW Torch
  3. TM #3 — Tungsten Electrodes
  4. TM #4 — Preparing GTAW Electrodes
  5. TM #5 — Causes of Poor Welds
  6. TM #6 — Example of a Good Weld

F. Workbook Supplements

  1. Workbook Supplement #1 — Interpret Uses of Aluminum Filler Metals
  2. Workbook Supplement #2 — Interpret Uses of Stainless Steel Filler Metals
  3. Workbook Supplement #3 — Discuss Gas Tungsten Arc Welded Aircraft Repairs

G. Answers to Workbook Supplements

H. Project Guides

  1. Project Guide #1 — Set Up and Shut Down Power Supply for Welding Aluminum
  2. Project Guide #2 — Set Up and Shut Down Power Supply for Welding Mild and Stainless Steel

## MODULE CONTENTS

    3. Project Guide #3 — Make Stringer Beads on $^{1}/_{16}$-Inch Aluminum with Filler Rod in Flat Position
    4. Project Guide #4 — Construct a Square-Groove Butt Weld on $^{1}/_{8}$-Inch Aluminum in Flat Position
    5. Project Guide #5 — Construct a Lap-Joint Fillet Weld on $^{1}/_{16}$-Inch Mild Steel with Filler Rod in Horizontal Position
    6. Project Guide #6 — Repair Damage in Mild Steel Tubing Using a Welded Patch

I. Theory Test

J. Answers to Theory Test

# AIRFRAME
# A204 AIRCRAFT WELDING
# PERFORM GAS TUNGSTEN ARC WELDING
# A204-D

## INTRODUCTION

Gas tungsten arc welding was once a special and uncommon type of welding process used in the average aircraft maintenance shop. Today it is the most common electric arc welding process used to join metals. The gas tungsten arc process (TIG or GTAW) is a versatile and highly controllable procedure. The torch, although it is electric, is used in the same manner as the oxyacetylene torch. The main difference is that the temperature within the arc of the TIG torch can be raised extremely high, and heat necessary to accomplish the welding task can be concentrated in a smaller area of the metal being joined. The weld is protected by an inert gas, which reduces the amount of cleaning necessary after the weld is completed and protects the weld from contamination. This module will introduce you to the basics of this very practical skill.

## MODULE OBJECTIVE

After completion of this module, you will be able to set up and shut down equipment, weld common metals, and perform welded repairs to aircraft tubing using approved data. Your competency will be evaluated by completing workbook assignments, project guides, and by scoring a minimum of 85 percent on the module theory test.

# AIRFRAME
# A204 AIRCRAFT WELDING
# PERFORM GAS TUNGSTEN ARC WELDING
# A204-D

## SPECIFIC OBJECTIVES

After completion of this module, you will be able to:

| | | |
|---|---|---|
| 1. Match terms related to gas tungsten arc welding to their correct definitions. (1) | Technical Supplement #1 | |
| 2. Name applications of the gas tungsten arc welding process. (1) | EA-ITP-AB<br>Technical Supplement #2 | 202-203 |
| 3. Select from a list advantages of gas tungsten arc welding. (1) | EA-ITP-AB<br>Technical Supplement #2 | 202-203 |
| 4. Label the major controls and connections of the gas tungsten arc welding machine. (1) | Technical Supplement #2 | |
| 5. State the two types of welding current used most in gas tungsten arc welding and their usages. (1) | EA-ITP-AB<br>Technical Supplement #2 | 202-204 |
| 6. Label the major parts of a gas tungsten arc welding torch. (2) | Technical Supplement #2 | |
| 7. Name the most commonly used types of gas cups for gas tungsten arc welding. (1) | Technical Supplement #2 | |
| 8. Name the color, finish, size, and application when given the type of tungsten electrode. (2) | Technical Supplement #2 | |
| 9. Interpret uses of aluminum and stainless steel filler metals. (2) | EA-ITP-AB<br>Technical Supplement #2<br>Workbook Supplements #1 & #2 | 203-205 |
| 10. State facts related to the major metallurgical factors to be considered when welding. (1) | EA-ITP-AB<br>Technical Supplement #2 | 203-205 |
| 11. Match illustrations of poor welds to their causes. (2) | Technical Supplement #2 | |
| 12. Name characteristics of a good weld. (1) | Technical Supplement #2 | |
| 13. List the operational characteristics of argon and helium shielding gases used in the GTAW process. (1) | Technical Supplement #2 | |

## SPECIFIC OBJECTIVES

| | | |
|---|---|---|
| 14. Select statements related to welding repair methods. (1) | EA-ITP-AB<br>AC 65-15A<br>EA-ITP-AW<br>Workbook Supplement #3 | 205-209<br>276-283<br>3:IV:18-19 |
| 15. Set up and shut down power supply for welding aluminum. (2) | Project Guide #1 | |
| 16. Set up and shut down power supply for welding mild and stainless steel. (2) | Project Guide #2 | |
| 17. Make stringer beads on 1/16-inch aluminum with filler rod in flat position. (2) | Project Guide #3 | |
| 18. Construct a square-groove butt weld on 1/8-inch aluminum in flat position. (2) | Project Guide #4 | |
| 19. Construct a lap-joint fillet weld on 1/16-inch mild steel with filler rod in horizontal position. (2) | Project Guide #5 | |
| 20. Repair damage in mild steel tubing using a welded patch. (2) | Project Guide #6 | |

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# PERFORM GAS TUNGSTEN ARC WELDING
# A204-D

## INSTRUCTOR'S MODULE IMPLEMENTATION GUIDE

### I. Implementation Suggestions

(NOTE: Have students read all available resource material related to specific objectives.)

| Estimated Teaching Time | | Theory | Lab |
|---|---|---|---|
| Objective 1 | Using Technical Information Supplement #1, discuss the terms and definitions related to TIG welding. Use illustrations or examples when necessary. | | |
| Objective 2 | Use Technical Information Supplement #2 to discuss the three most common applications for TIG welding. Be sure to explain why the TIG process is the more desirable process to be used for these applications. | | |
| Objective 3 | Use Technical Information Supplement #2. List the advantages of TIG welding on a flip chart. Use creative illustrations to emphasize each advantage. | | |
| Objective 4 | Using Transparency Master #1, Technical Information Supplement #2, and the actual welding unit, point out the major controls of the TIG unit and explain briefly how the controls are used in various welding situations. | | |
| Objective 5 | Use Technical Information Supplement #2 to explain the two types of current used in TIG welding and their usages. Be sure to explain why these currents are used on the specific metals. | | |
| Objectives 6-7 | Identify the six major parts of the TIG welding torch. Use Transparency Master #2 and Technical Information Supplement #2. Allow the students to view a disassembled torch. When the gas cup is identified, name the three commonly used gas cups. | | |

| Estimated Teaching Time | | Theory | Lab |
|---|---|---|---|
| Objective 8 | Show Transparency Master #3 to explain how the tungsten electrodes are classified according to color, finish, type, and size. Have the students review Technical Information Supplement #2, Section G, and explain the applications for the various electrodes. Show Transparency Master #4, and explain how the tungsten electrode is prepared for use. | | |
| Objective 9 | Have students examine the charts in Technical Information Supplement #2, Section H. Instruct the class on how to interpret the charts. Point out the most frequently used filler metals for steel and aluminum. Have students complete Workbook Supplements #1 and #2. | | |
| Objective 10 | Explain the major metallurgical factors to be considered when welding aluminum, stainless steel, titanium, and magnesium. | | |
| Objective 11 | Show the class examples of poor welds, and explain the causes for the defects. Use Transparency Master #5 and Technical Information Supplement #2. | | |
| Objective 12 | State the five characteristics of a good weld. Use Transparency Master #6 and Technical Information Supplement #2. | | |
| Objective 13 | Discuss the characteristics of the inert shielding gases, argon and helium, used in the TIG welding process. Use Technical Information Supplement #2. | | |
| Objective 14 | Explain the welded repairs which can be performed on aircraft structures. Discuss the procedures for accomplishing these repairs. Explain why it is sometimes advantageous to simply replace a structural component instead of repairing it. Have examples of the most common welded repairs for the students to examine. Have students review the remainder of Technical Information Supplement #2 and complete Workbook Supplement #3 and EA-ITP-AW 3:IV:18-19. | | |

# INSTRUCTOR'S MODULE IMPLEMENTATION GUIDE

| Estimated Teaching Time | | Theory | Lab |
|---|---|---|---|
| Objectives 15-20 | Discuss Project Guides #1-#6 with the class; review all pertinent safety rules and precautions, and demonstrate all procedures. Have students complete the projects. Review the projects in class after all students have completed. | | |

## AIRFRAME
## A204 AIRCRAFT WELDING
## PERFORM GAS TUNGSTEN ARC WELDING
## A204-D

### TECHNICAL INFORMATION SUPPLEMENT #1 — Terms and Definitions

A. Gas tungsten arc welding — Arc welding process wherein coalescence is produced by heating with an arc between a nonconsumable tungsten electrode and the base metal utilizing an inert gas, argon or helium, that shields the weld zone from contamination by oxygen and nitrogen in the air

(NOTE: TIG is a common term used to describe this process.)

B. Inert shielding gas — Gas which will not combine with other gases

(NOTE: Inert shielding gas is used to surround the weld zone and prevent contamination of the weld by oxygen and nitrogen in the air.)

C. Tungsten electrode — Practically nonconsumable welding electrode used to create an intense arc between the tip of the electrode and the work

D. High frequency current — High-voltage, low-power source introduced into the AC weld current to start the arc and aid in oxide removal when welding aluminum

E. Flowmeter — Calibrated metering device used to regulate the flow of gases to the torch; measures gas flow in cubic feet per hour

F. Collet — Chucking device used to hold the tungsten in the torch

G. Collet body — Holding device for the collet

H. Foot control — Device used by the welder to control welding current during the welding process

I. Gas cup — Attachment that fits on the end of the GTAW torch to direct the flow of shielding gas to the tungsten and weld zone

J. Porosity — Gas pockets or voids in metal

K. Thermal conductivity — Characteristic of a metal to conduct heat throughout its thickness, width, and length

L. Metallurgy — Science and technology of metals

M. Aluminum oxide — Thin film that forms on the surface of aluminum due to a reaction between the metal and oxygen in the air

# AIRFRAME
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## TECHNICAL INFORMATION SUPPLEMENT #2 — Fundamentals of Gas Tungsten Arc Welding

A. Applications of GTAW

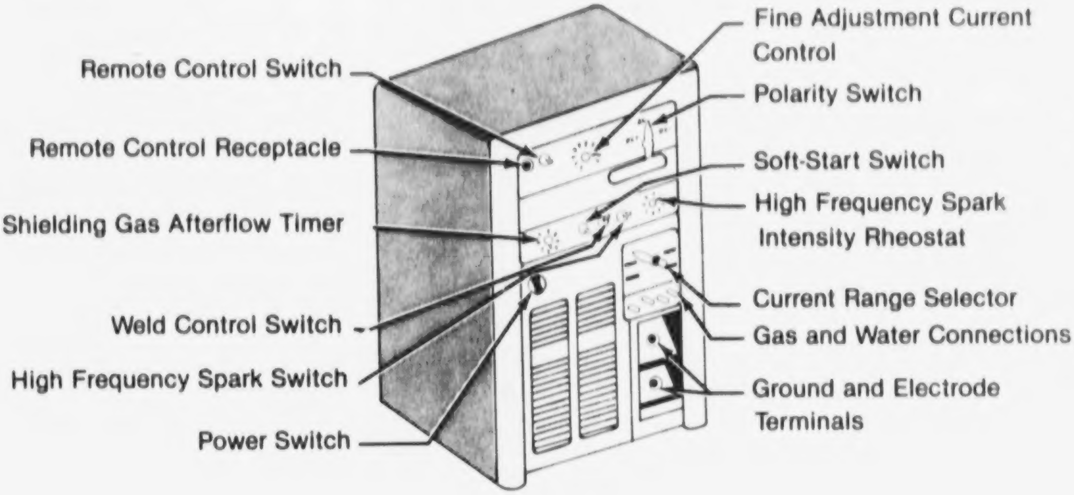
1. Makes top quality welds possible on most metals and alloys used in industry
2. Makes welds possible in all positions through wide range of metal thickness
3. Used particularly for aluminum and its alloys (even on very thin sections)

B. Advantages of GTAW

1. No flux used and no post cleaning required
2. Arc and weld puddle clearly visible to welder
3. No slag or spatter
4. Makes excellent root pass on carbon and stainless steel pipe
5. Minimum of distortion and stress with heat concentrated in small area
6. Welder has very close control of welding current

C. GTAW welding machine controls and connections (Figure 1)

FIGURE 1


Remote Control Switch
Remote Control Receptacle
Shielding Gas Afterflow Timer
Weld Control Switch
High Frequency Spark Switch
Power Switch
Fine Adjustment Current Control
Polarity Switch
Soft-Start Switch
High Frequency Spark Intensity Rheostat
Current Range Selector
Gas and Water Connections
Ground and Electrode Terminals

## TECHNICAL INFORMATION SUPPLEMENT #2

1. Remote control switch

   (NOTE: This control can be placed in either remote or manual position.)

2. Remote control receptacle

   (NOTE: This is the receptacle for the foot control lead.)

3. Shielding gas afterflow timer

   (NOTE: The post-purge can be regulated to occur for 0 to 60 seconds.)

4. Weld control switch

   (NOTE: This control is set for either SMAW or GTAW welding.)

5. High frequency spark switch

   (NOTE: The adjustment positions for this control are *off*, *start only*, and *continuous*.)

6. Power switch

7. Fine adjustment current control

8. Polarity switch

   (NOTE: This control is adjusted according to type of current to be used—either AC, DCSP, or DCRP.)

9. Soft-start switch

   (NOTE: The soft start reduces the initial starting current.)

10. High frequency spark intensity rheostat

11. Current range selector

12. Gas and water connections

    (NOTE: Solenoid valves are used for these connections, and there are "in" and "out" connections for both the gas and the water.)

13. Ground and electrode terminals

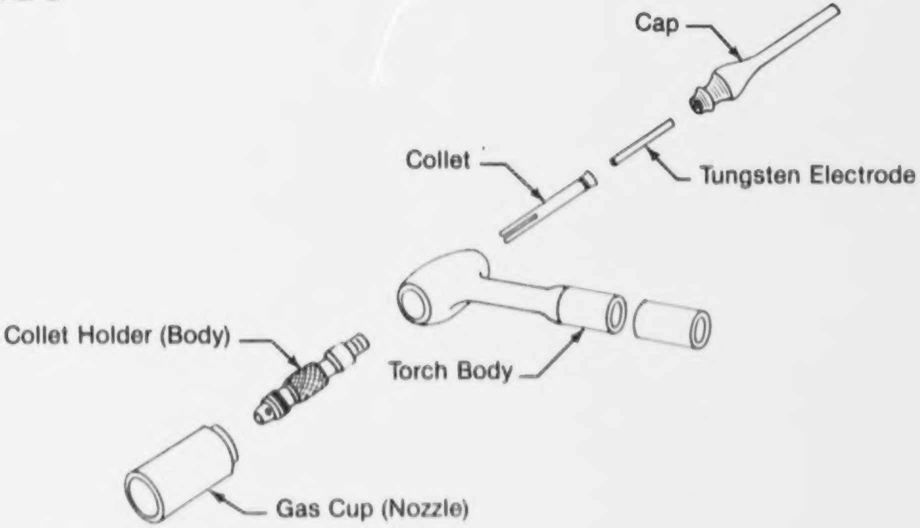
D. GTAW currents and their usages

   1. Alternating current (AC) with high frequency for aluminum and magnesium

   2. Direct current straight polarity (DCSP) for mild and stainless steel

E. Major parts of GTAW torch (Figure 2)

FIGURE 2


Cap
Collet
Tungsten Electrode
Collet Holder (Body)
Torch Body
Gas Cup (Nozzle)

1. Cap

   (NOTE: The cap holds and tightens the tungsten electrode in the collet.)

2. Electrode

   (NOTE: The electrode is the tungsten.)

3. Collet

   (NOTE: The collet holds the tungsten electrode.)

4. Collet holder (body)

   (NOTE: This holds the collet and has threads for holding the gas cup.)

5. Gas cup (nozzle)

   (NOTE: The gas cup directs the flow of shielding gas around the tungsten to the weld zone preventing contamination of the electrode and the weld.)

6. Torch body

F. Types of cups (nozzles)

(NOTE: Ceramic and glass nozzles are expensive and easily broken. *Handle them with care.*)

1. Ceramic

   (NOTE: This type of cup is the least expensive and most popular.)

2. Pyrex glass

   (NOTE: Pyrex glass is transparent.)

3. Metal

   (NOTE: Metal cups are usually copper.)

G. Types of tungsten electrodes (Table 1)

(NOTE: Tungsten electrodes have a high melting point [6900°F] and are practically nonconsumable. The electrode should never touch the molten weld puddle. Electrodes contaminated by contact with weld puddle must be reground or they produce a sputtering arc and weld contamination.)

TABLE 1: Tungsten electrodes

| Type of Electrode | Color | Finish | Sizes | Application |
|---|---|---|---|---|
| Pure | Green | Ground or chemically etched | 1/16, 3/32, 1/8, 5/32, 3/16, 1/4 | Aluminum and magnesium |
| 1% Thoriated | Yellow | Ground or chemically etched | 1/16, 3/32, 1/8, 5/32, 3/16, 1/4 | Mild or stainless steel |
| 2% Thoriated* | Red | Ground or chemically etched | 1/16, 3/32, 1/8, 5/32, 3/16, 1/4 | Mild or stainless steel |
| Zirconiated | Brown | Ground or chemically etched | 1/16, 3/32, 1/8, 5/32, 3/16, 1/4 | X-ray quality for aluminum or magnesium |

*Most common electrode for mild and stainless steel

H. GTAW filler metals

1. Aluminum (See Table 2)

# TECHNICAL INFORMATION SUPPLEMENT #2

## TABLE 2: Guide to the choice of filler metal for GTAW welding aluminum

| | | M | L | K | J | I | H | G | F | E | D | C | B | A |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Casting alloys | | | | | | | | | | | | |
| | Base metal | 43, 355, 356 | 214,A214 B214,F214 | 6061, 6062, 6063, 6151 | 5456 | 5454 | 5154, 5254(1) | 5086, 5356 | 5083 | 5052, 5652(1) | 5005, 5050 | 3004, CLAD 3004 | 1100, 3003, CLAD 3003 | 1060 |
| A | 1060 | ER4043 | ER4043 | ER4043 | ER5356 (3),(5) | ER4043 | ER4043 | ER5356 (3),(5) | ER5356 | ER4043 | ER1100 (3) | ER4043 | ER1100 (3) | ER1260 |
| B | 1100,3003 CLAD 3003 | ER4043 | ER4043 (5) | ER4043 (5) | ER5356 (3),(5) | ER4043 (5) | ER4043 (5) | ER5356 (3),(5) | ER5356 (3),(5) | ER4043 (5) | ER4043 (5) | ER4043 (5) | ER1100 (3) | |
| C | 3004, CLAD 3004 | ER4043 | ER4043 (5) | ER4043 (2) | ER5356 (5) | ER5356 (3),(5) | ER5356 (5) | ER5356 (5) | ER5356 (5) | ER5356 (3),(5) | ER4043 (5) | ER4043 (4),(5) | | |
| D | 5005, 5050 | ER4043 | ER4043 (5) | ER4043 (2) | ER5356 (5) | ER4043 (5) | ER5356 (3),(5) | ER5356 (5) | ER5356 (5) | ER4043 (5) | ER4043 (4),(5) | | | |
| E | 5052, 5652(1) | ER4043 (5) | ER4043 (2) | ER4043 (2) | ER5356 (5) | ER5356 (2),(3) | ER5356 (2) | ER5356 (5) | ER5356 (5) | ER5652 (2),(3) | | | | |
| F | 5083 | ER5356 (3),(5) | ER5356 (5) | ER5356 (5) | ER5183 (5),(6) | ER5356 (5) | ER5356 (5) | ER5356 (5) | ER5183 (5),(6) | | | | | |
| G | 5086, 5356 | ER5356 (3),(5) | ER5356 (5) | ER5356 (5) | ER5356 (5) | ER5356 (5) | ER5356 (5) | ER5356 (5) | | | | | | |
| H | 5154 5254(1) | ER5356 (3),(5) | ER5356 (2) | ER5356 (2),(3) | ER5356 (5) | ER5356 (2) | ER5254 (2) | | | | | | | |
| I | 5454 | ER5356 (3),(5) | ER5356 (2) | ER5356 (2),(3) | ER5356 (5) | ER5554 (5) | | | | | | | | |
| J | 5456 | ER5356 (3),(5) | ER5356 (5) | ER5356 (5) | ER5556 (5),(6) | | | | | | | | | |
| K | 6061,6062 6063,6151 | ER4043 (5) | ER5356 (2),(3) | ER5356 (2),(3) | | | | | | | | | | |
| L | 214,A214 B214,F214 | ER4043 (5) | ER5356 (2) | | | | | | | | | | | |
| M | 43, 355, 356 | ER4043 (4) | | | | | | | | | | | | |

(NOTE: The composition of the filler metal should be matched to that of the base metal. The size of the filler metal rod is determined by the thickness of base metal and welding current.)

(1) Base metal alloys 5652 and 5254 are used for hydrogen peroxide service. ER5254 filler metal is used for welding both alloys for low temperature service (150° F and below.) ER5652 filler metal is used for welding 5652 for high temperature service (150° F and above).

(2) ER5154, ER5254, ER5183, ER5356, ER5554, and ER5556 may be used. In some cases, they provide: 1—improved color match after anodizing treatment, 2—highest weld ductility, and 3—higher weld strength. ER5554 is suitable for elevated temperature service.

(3) ER4043 may be used for some applications.

(4) Filler metal with the same analysis as the base metal is sometimes used.

(5) ER5356, ER5183, or ER5556 may be used.

(6) ER5356 is the third choice.

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2. Stainless (Table 3)

TABLE 3: Stainless steel filler metal guide for GTAW and GMAW welding

| AISI Type | Typical Wire Composition (1) | | | | | | Applications |
|---|---|---|---|---|---|---|---|
| | C | Mn | Si | Cr | Ni | Others | |
| 308L (2) | .025 | 1.8 | .40 | 20.6 | 9.7 | . . . | For welding types 304, 308, 321 & 347 |
| 308L Hi Sil (2) | .025 | 1.8 | .85 | 20.6 | 9.7 | . . . | For welding types 301, 304, particularly piping |
| 309L (2) | .025 | 1.8 | .40 | 24.0 | 13.5 | . . . | For welding 309 and straight chromium grades when heat treatment is not possible |
| 310 | .12 | 1.8 | .45 | 26.0 | 21.0 | . . . | For welding 310, 304 clad and stainless overlay (3) |
| 316L (2) | .025 | 1.8 | .35 | 19.5 | 13.0 | 2.3 Mo | For welding type 316L |
| 316L Hi Sil (2) | .025 | 1.8 | .85 | 19.5 | 13.0 | 2.3 Mo | For welding type 316, particularly piping |
| 317L (2) | .025 | 1.8 | .40 | 19.0 | 12.5 | 3.3 Mo | For welding type 317 |
| 347 | .06 | 1.3 | .40 | 19.5 | 9.5 | .90 Cb | For welding types 321 and 347 where maximum corrosion resistance is required |

(1) Remainder is iron.
(2) Hi Sil means "higher than normal silicon" (approximately double); L means "low carbon" (0.03 maximum carbon).
(3) Clad means that the metal is overlayed with stainless.

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## TECHNICAL INFORMATION SUPPLEMENT #2

I. Welding metallurgy

1. Aluminum

   a. Melting point — Aluminum melts at 1220°F but requires higher welding current than other metals due to its high thermal conductivity

      (NOTE: Aluminum dissipates heat away from the weld zone five times faster than steel. This requires a high heat input [amperage] to obtain a puddle. It also means the weld puddle solidifies [sets up] faster and makes out-of-position welding easier.)

   b. Aluminum oxide — Forms on the surface of aluminum when exposed to oxygen in the air; this oxide requires a temperature of 3700°F to melt or break down

      (NOTE: At welding temperatures, oxygen in the air combines with the exposed aluminum to reform the oxide. With inert gas to shield the weld zone and the reverse polarity cycle of AC current to remove the oxide, the problem is eliminated.)

   c. Heat colors — Aluminum shows no heat colors as it approaches the melting point

      (NOTE: With the GTAW process, the metal takes a shiny or wet appearance when melting occurs.)

   d. Proper mechanical support — Since some aluminum alloys melt at 900°F, care must be taken to support all areas subjected to the extreme heat of welding to prevent collapse, warping, and distortion

2. Stainless steel

   a. Thermal conductivity — Stainless steel dissipates heat from the weld zone 40 to 50 percent slower than mild steel

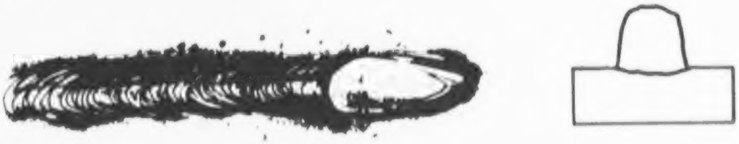
   b. Distortion — Heat expansion in the weld zone is so slow that weld metal warpage is a problem

      (NOTE: Jigs and backup bars can be used to effectively dissipate the heat from the weld zone and thereby reduce stresses and warpage, plus improve the mechanical properties of the weld.)

J. Causes of poor welds (Figures 3-7)

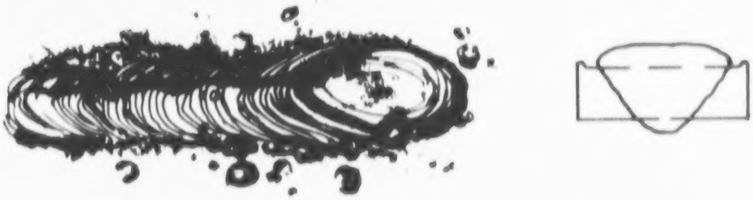
1. Welding current too low

FIGURE 3



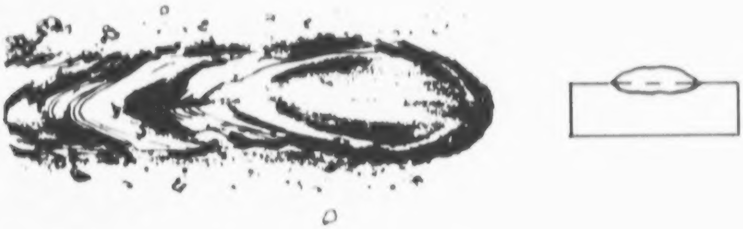
2. Welding current too high

FIGURE 4



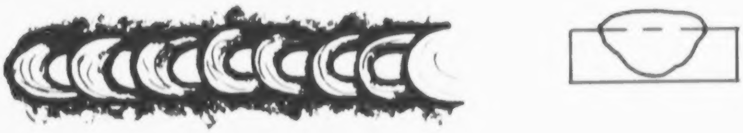
3. Arc too long (voltage too high)

FIGURE 5



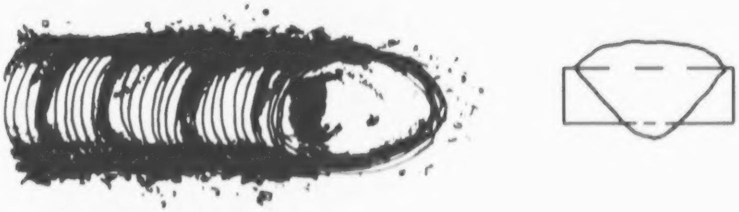
4. Welding speed too fast

FIGURE 6



5. Welding speed too slow

FIGURE 7



6. Contaminated tungsten

K. Characteristics of a good weld

1. Smooth edge
2. Correct bead size
3. Even penetration
4. Even ripple
5. Clean, bright weld

L. Operational characteristics of argon and helium

1. Argon

   (NOTE: Argon is the most popular gas for GTAW.)

   a. Easily obtainable at low cost

   b. Better shielding at lower flow rates than helium

      (NOTE: Argon is ten times heavier than helium)

   c. Easier arc starting than helium

   d. Better cleaning action when welding aluminum with AC current

2. Helium

   (NOTE: Helium is used when welding thicker metals.)

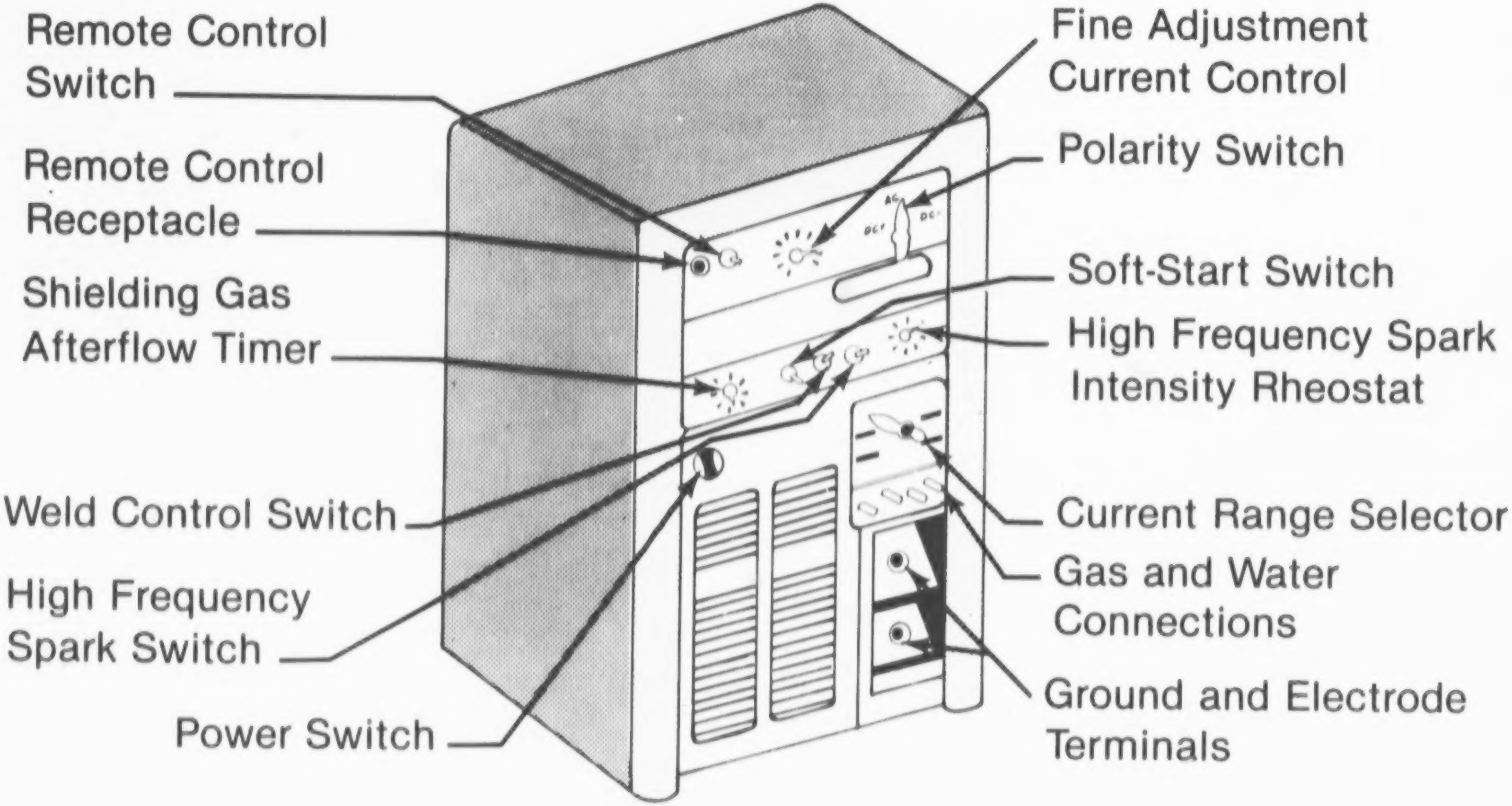
   a. Yields higher heat for comparable current than argon

   b. Arc length is more critical than argon

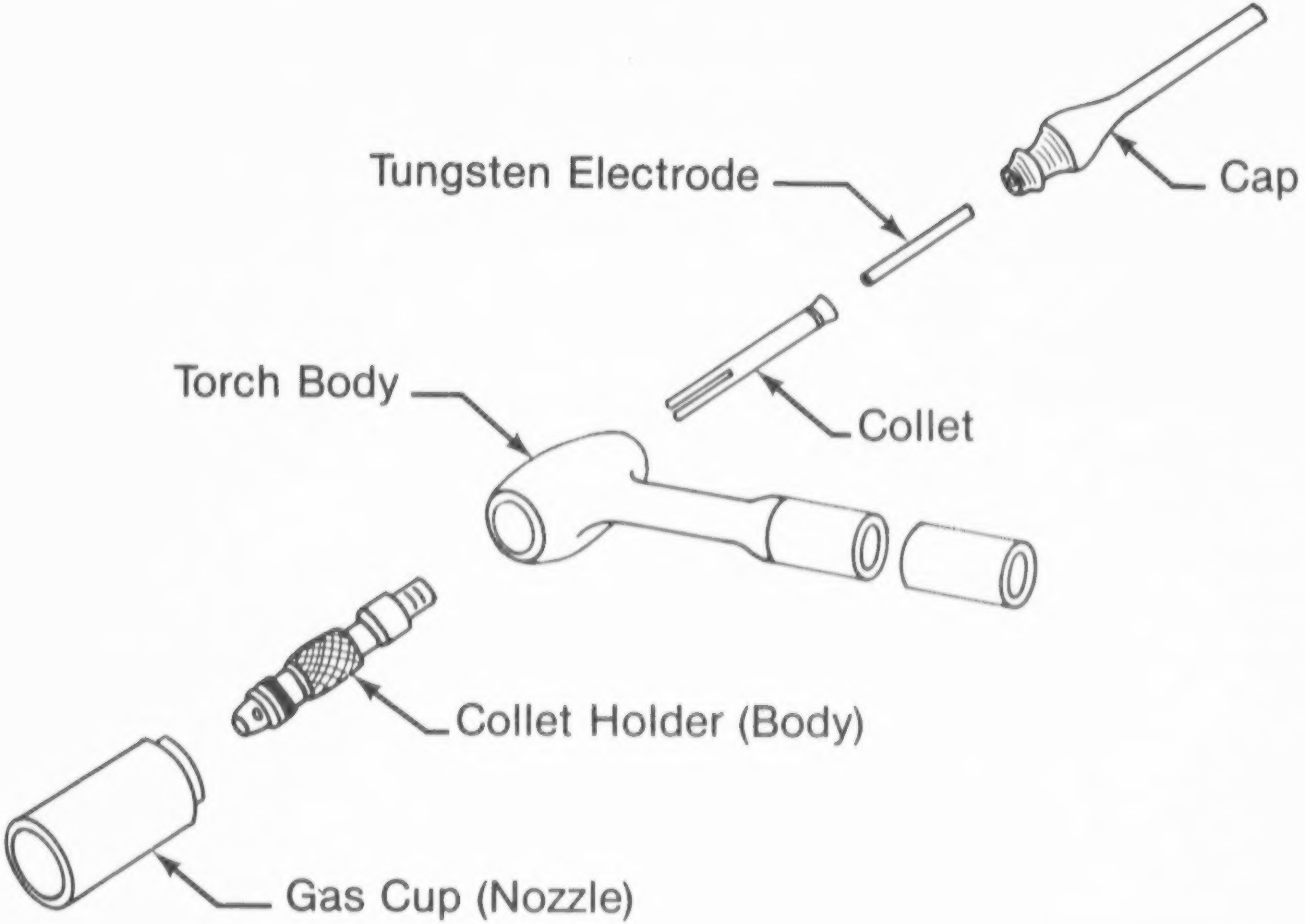
   c. Has higher welding speeds than argon

   d. Produces poor arc stability and cleaning action

# GTAW Welding Machine


Remote Control Switch
Remote Control Receptacle
Shielding Gas Afterflow Timer
Weld Control Switch
High Frequency Spark Switch
Power Switch
Fine Adjustment Current Control
Polarity Switch
AC
DC+
DC-
Soft-Start Switch
High Frequency Spark Intensity Rheostat
Current Range Selector
Gas and Water Connections
Ground and Electrode Terminals

# GTAW Torch


Tungsten Electrode
Cap
Torch Body
Collet
Collet Holder (Body)
Gas Cup (Nozzle)

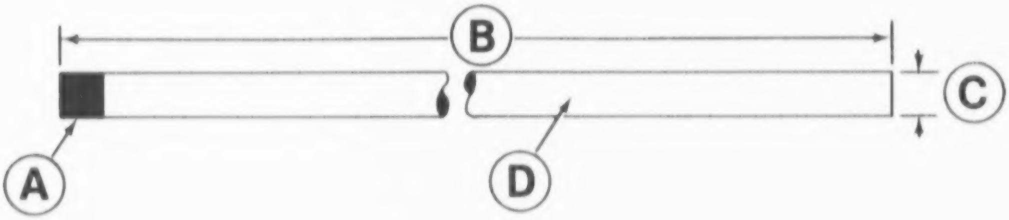
A204D-25

TM #2

# Tungsten Electrodes

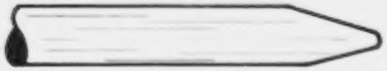
## Electrodes Available

| Color Code Ⓐ | Metal or Alloy |
|---|---|
| Green | Pure Tungsten |
| Yellow | 1% Thorium |
| Red | 2% Thorium |
| Brown | Zirconium |

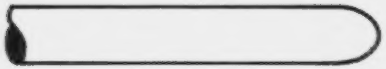


| Ⓑ Lengths | Ⓒ Standard Diameters | Ⓓ Finish |
|---|---|---|
| 3" | 1/16" | Ground |
| 6" | 3/32" | Chemically Etched |
| 7" | 1/8" | |
| 18" | 5/32" | |
| 24" | 3/16" | |
| | 1/4" | |

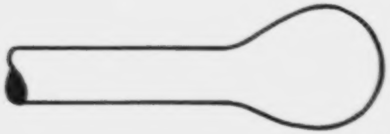
# Preparing GTAW Electrodes

A 

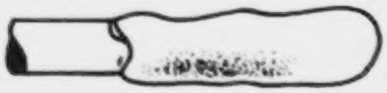
**Good Condition**—Dull Point with Grind Marks Running Lengthwise (Steel and Stainless)

B 

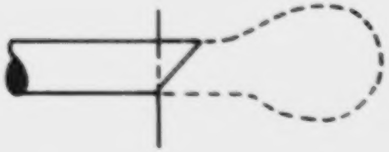
**Good Condition**—Shiny, Round End (Aluminum and Magnesium)

C 

**Too Much Current**—Match-Head Shape

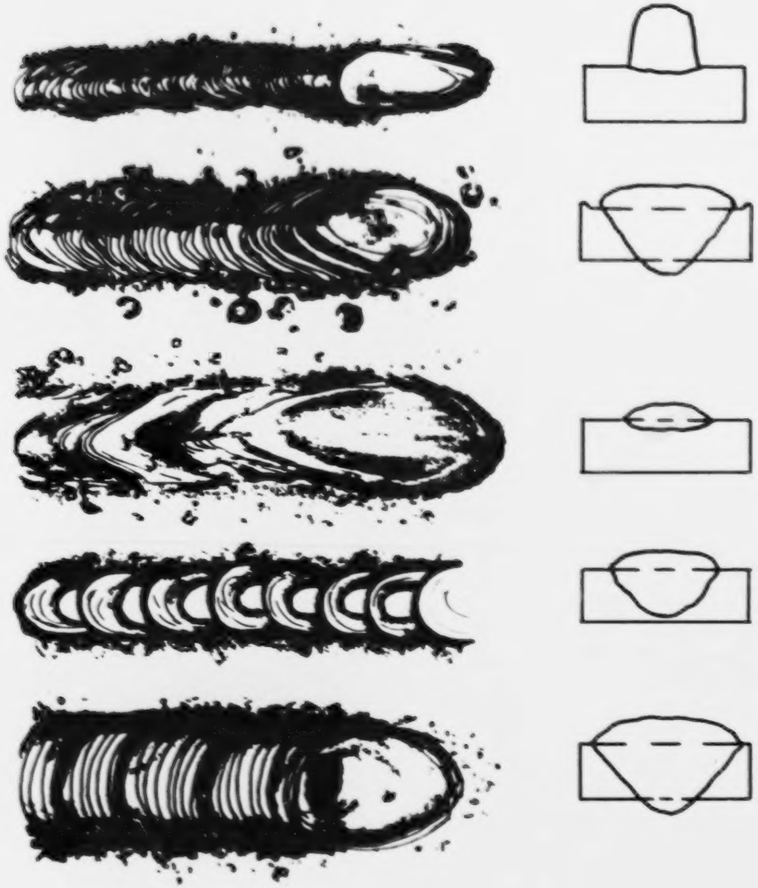
D 

**End Contaminated with Base Metal**—Electrode Touched Puddle or Filler Rod (Similar to **C**, But Uneven and Longer)

E 

Break off ends at dotted lines if condition **C** or **D** exists. If electrode breaks at angle, grind off flat.

# Causes of Poor Welds



Welding Current Too Low

Welding Current Too High

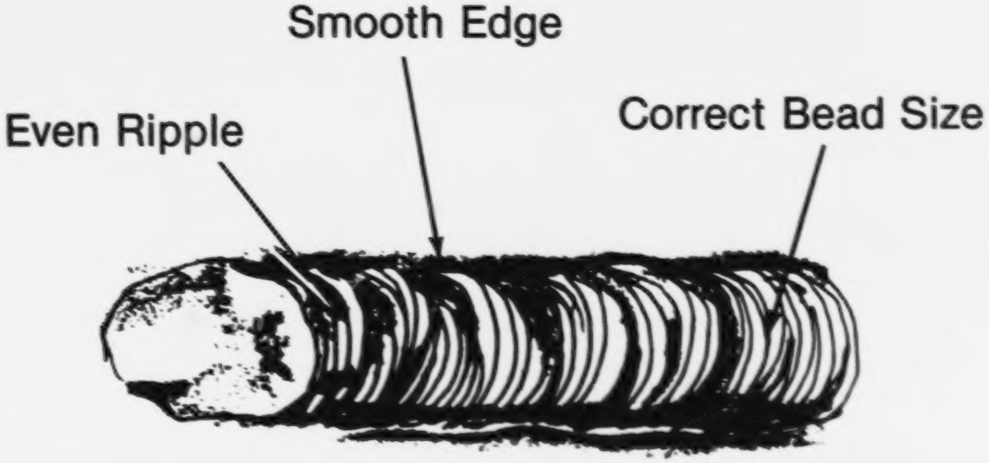
Arc Too Long (Voltage Too High)

Welding Speed Too Fast

Welding Speed Too Slow

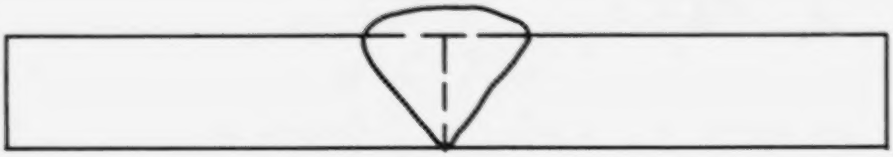
# Example of a Good Weld

Top View


Smooth Edge
Even Ripple
Correct Bead Size

Clean, Bright Weld

End View



Even Penetration

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## WORKBOOK SUPPLEMENT #1 — Interpret Uses of Aluminum Filler Metals

Selecting the proper filler rod is best accomplished by applying knowledge learned through study and experience and by interpreting existing charts on base metal/filler rod relationships. This workbook supplement will help you to gain knowledge, experience, and the skills required to utilize manufacturers' charts to select appropriate filler metals.

Using Table 2 in Technical Information Supplement #2, answer the following questions.

A. What filler metal should be used to weld base metal 3004?

B. What filler metal should be used to weld base metals 6061, 6062, 6063, and 6151?

C. What type of filler metal would be required for 5456 base metal?

D. What filler metal would be used for 5052 base metal?

E. What filler metal would be used for base metal 3003?

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## WORKBOOK SUPPLEMENT #2 — Interpret Uses of Stainless Steel Filler Metals

This workbook supplement will help you to draw conclusions about the similarities and differences in the materials used to join different metals. You will also gain skill in interpreting manufacturers' data.

Using Table 3 in Technical Information Supplement #2, answer the following questions.

A. For welding type 304 stainless,

1. What would be the correct filler rod?

______________________________________________

2. How much chromium does it contain?

______________________________________________

B. Type 347 stainless, where maximum corrosion resistance is required, requires what type of filler rod?

______________________________________________

C. Type 316L stainless requires what type of filler rod?

______________________________________________

D. Type 308 stainless requires what type of filler rod?

______________________________________________

E. Type 310 filler metal will be used on what type of base metal?

______________________________________________

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# A204-D

## WORKBOOK SUPPLEMENT #3 — Discuss Gas Tungsten Arc Welded Aircraft Repairs

"Welding is a small part of the total job function of an A&P mechanic, but it is also one that demands both knowledge and skill and one that requires practice to maintain that skill," says Dale Crane, author of *Airframe Section Textbook*, EA-ITP-AB. The repairs discussed in the text are some of the most common types of repairs made to the aircraft structure. Remember that you are responsible for consulting the manufacturers' manuals and using their approved data for any repair being made. This workbook supplement will enable you to utilize your knowledge related to welded aircraft repair methods.

A. List three criteria to be considered in performing a welded-type repair.

1. ____________________________________________

____________________________________________

2. ____________________________________________

____________________________________________

3. ____________________________________________

____________________________________________

B. Discuss your knowledge of dents at a cluster weld and dents between cluster welds by answering the following questions.

1. How far should a patch plate extend beyond the damage and up the tubes from the dent-type damage occurring at a cluster weld?

____________________________________________

____________________________________________

2. For the repair described in question 1, describe how the patch plate is prepared and fit up to the tube.

____________________________________________

____________________________________________

____________________________________________

____________________________________________

3. What is the most common way of repairing a dent between clusters?

4. The end of the welded sleeve should have a scarf angle of how many degrees?

5. When using a fish-mouth-type reinforcement to repair a dent between clusters, what type of weld is used to increase the bond of the repair metal to the damaged tube?

6. When may a welded patch be used on damage between clusters?

C. Select the best answer related to a tube-splice repair performed with an inner- or outer-sleeve reinforcement. Circle the letters before the correct answers.

1. When preparing a sleeve to be used as an inner reinforcement for a repair, how long should the sleeve be?

   a. Five times as long as the tube diameter

   b. Ten times as long as the tube wall thickness

   c. Seven times as long as the damage

   d. Seven times as long as the tube diameter

2. What are the dimensional requirements for a reinforcing tube to be used as an outer-sleeve type reinforcement?

   a. The inside diameter of the reinforcing tube must be no greater than 1/8 inch more than the outside diameter of the original

   b. The inside diameter of the reinforcing tube must be no greater than 1/16 inch more than the outside diameter of the original

   c. The inside diameter of the reinforcing tube must be no greater than 1/4 inch more than the outside diameter of the original

   d. The inside diameter of the reinforcing tube must be no greater than 1/32 inch more than the outside diameter of the original

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## ANSWERS TO WORKBOOK SUPPLEMENTS

### Workbook Supplement #1

A. ER4043
B. ER5356
C. ER5556
D. ER5652
E. ER1100

### Workbook Supplement #2

A. 1. 308L
   2. 20.6
B. 347
C. 316L
D. 308L
E. 310, 304 clad and stainless overlay

### Workbook Supplement #3

A. 1. Determine the type of steel to be used for the repair
   2. Design the repair so that it will conform to approved data
   3. Fit up the repair carefully

B. 1. 1 1/2 diameters of the tube beyond the damage, and 1 1/2 diameters up the tubes from the damage
   2. Tack weld the patch in place, and heat it and form it to the contour of the tubing so there will be no space between the edge of the patch and the tube, then weld it in place
   3. By welding a sleeve over the damage
   4. 30 degrees
   5. Rosette weld
   6. When the dent is no deeper than 1/10 of the tube diameter and does not involve more than 1/4 of the tube circumference and does not have any cracks or sharp edges

C. 1. a
   2. b

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## A204-D

### PROJECT GUIDE #1 -- Set Up and Shut Down Power Supply for Welding Aluminum

PURPOSE: To develop competency in the skills of setting up and shutting down the power supply in gas tungsten arc welding.

REFERENCE MANUAL: Manufacturer's manual for gas tungsten arc welding machine

EQUIPMENT AND TOOLS:

A. GTAW welding machine with water-cooled torch, with or without foot control

B. Collet and collet holder of correct size

C. Nozzle of correct size

D. Protective clothing

E. Safety goggles or glasses

F. Welding helmet

SUPPLIES AND MATERIALS:

A. Argon

B. Pure or zirconiated tungsten electrode of correct size

C. Selection of aluminum filler rods

D. Welding grade aluminum

PROCEDURE:

(NOTE: Safety glasses or goggles should be worn in the shop at all times.)

A. Set up power supply

(NOTE: These procedures are applicable to most GTAW operations; however, always consult the manufacturer's maintenance manual for specific control adjustments.)

1. Set current range selector depending on metal thickness to low (2-60 amps), medium (10-250 amps), or high (20-300 amps)

2. Set fine adjustment current control to maximum setting within selected range if foot control is used

(NOTE: If machine is used without foot control, a specific current adjustment will be necessary as all current control will be manual at the machine.)

3. Set polarity switch to AC

4. Set weld control switch to GTAW

5. Set high frequency controls

   (NOTE: Welding machines not equipped with high frequency will not have these controls. If these controls are not on the machine, check the manufacturer's maintenance manual. Also, if the machine does not have high frequency, it will be necessary to have a copper starting block to avoid contamination of tungsten when striking arc.)

   a. Set high frequency spark switch to CONTINUOUS

   b. Set high frequency spark intensity rheostat to medium setting

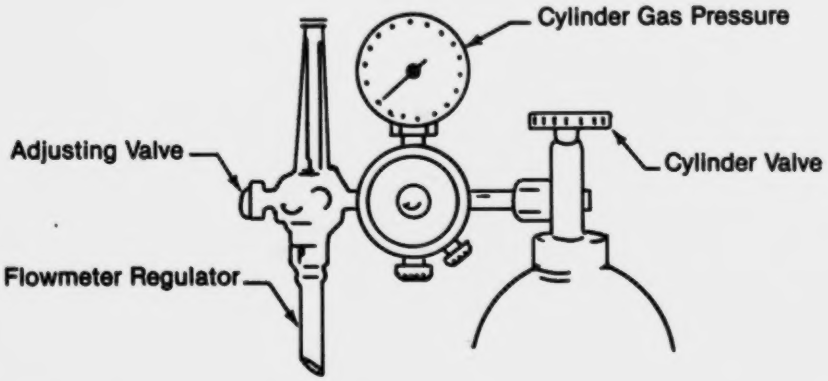
6. Switch power to ON

7. Standing to one side of cylinder, slowly open cylinder valve until fully open

8. Adjust shielding gas flow rate to 15 to 20 cfh (Figure 8)

   (NOTE: This is measured at the top of the ball.)

FIGURE 8



9. Adjust gas afterflow (post-purge) timer to 15 seconds

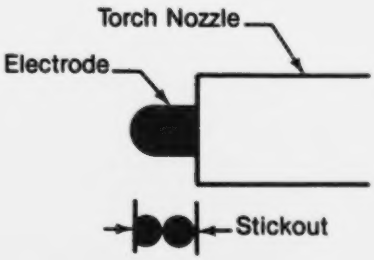
10. Set soft-start switch to ON

11. Set foot control switch to REMOTE (if equipped)

B. Adjust electrode stickout so that electrode sticks out a length of 1 ½ times electrode diameter from torch nozzle (Figure 9)

(NOTE: Stickout distance can be increased when welding T-joints, groove welds, or other hard-to-reach joints. Gas flow rates should be increased accordingly. Prepared tungsten should have a shiny, balled end. See Figure 9.)

FIGURE 9



1 ½ to 2 Times Electrode Diameter

C. Connect ground clamp to base metal

D. Select correct filler rod size from Table 4 at end of project guide

E. Shut down welding machine

1. Place torch where it will not arc or fall on floor

   (NOTE: GTAW torches are delicate and expensive, and they should be handled with care.)

2. Close gas cylinder valve

3. Depress foot control (if equipped) to bleed gas line

4. Close gas flow adjusting valve

   (NOTE: The ball will rest at the bottom of the gauge when the adjusting valve is closed.)

5. Turn power switch to OFF

F. Clean work area and return tools and equipment to proper storage area, or prepare for next project as directed by instructor

# PROJECT GUIDE #1

TABLE 4: Gas tungsten arc (TIG) welding of aluminum

| Material Thickness | | Type of Weld (1) | Tungsten Electrode Dia. (2) | Filler Rod Dia. | Nozzle Size I.D. | Shielding Gas C.F.H. (3) | Welding Current (Amps) AC-HF (4) | Number of Passes | Travel Speed (I.P.M.) |
|---|---|---|---|---|---|---|---|---|---|
| 3/64 | .046 | Sq. groove | 1/16 | 1/16 | 1/4 | 19 | 40-60 | 1 | 16 |
| 1/16 | .063 | Sq. groove | 3/32 | 3/32 | 5/16 | 19 | 70-90 | 1 | 11 |
| 1/16 | .063 | Fillet | 3/32 | 3/32 | 5/16 | 15 | 70-90 | 1 | 9 |
| 3/32 | .094 | Sq. groove | 3/32 | 3/32 | 5/16 | 19 | 90-110 | 1 | 11 |
| 3/32 | .094 | Fillet | 3/32 | 3/32 | 5/16 | 16 | 95-115 | 1 | 9 |
| 1/8 | .125 | Sq. groove | 1/8 | 1/8 | 3/8 | 20 | 115-135 | 1 | 11 |
| 1/8 | .125 | Fillet | 1/8 | 1/8 | 3/8 | 19 | 120-140 | 1 | 10 |
| 3/16 | .187 | Fillet | 5/32 | 5/32 | 7/16 | 25 | 180-200 | 1 | 10 |
| 3/16 | .187 | V-groove | 5/32 | 7/16 | 7/16 | 25 | 160-180 | 2 | 11 |
| 1/4 | .250 | Fillet | 3/16 | 3/16 | 1/2 | 30 | 230-250 | 1 | 10 |
| 1/4 | .250 | V-groove | 5/32 | 5/32 | 7/16 | 30 | 200-220 | 2 | 9 |
| 3/8 | .375 | Fillet | 3/16 | 3/16 | 1/2 | 35 | 250-310 | 2-3 | |

(1) Data is for all welding positions.

(2) For tungsten electrodes—1st choice—pure tungsten green strip; 2nd choice—zirconated brown strip.

(3) Normally argon is used for shielding, however, mixtures of 10% or more helium with argon are sometimes used for increased penetration in aluminum 1/4 inch thick and over. The gas flow should be increased when helium is added. A mixture of 75% He + 25% argon is popular. When 100% helium is used, gas flow rates are about twice those used for argon.

(4) Increase amperage when backup is used.

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# A204-D

## PROJECT GUIDE #2 — Set Up and Shut Down Power Supply for Welding Mild and Stainless Steel

PURPOSE: To develop competency in the skills of setting up and shutting down the power supply for welding mild and stainless steel in gas tungsten arc welding.

REFERENCE MANUAL: Manufacturer's manual for gas tungsten arc welding machine

EQUIPMENT AND TOOLS:

A. GTAW welding machine with water-cooled torch, with or without foot control

B. Collet and collet holder (body) of correct size

C. Nozzle of correct size

D. Protective clothing

E. Safety goggles or glasses

F. Welding helmet

SUPPLIES AND MATERIALS:

A. Argon

B. 1% or 2% thoriated tungsten electrode of correct size

C. Selection of stainless and mild steel filler rods

PROCEDURE:

(NOTE: Safety glasses or goggles should be worn in the shop at all times.)

A. Set up power supply

(NOTE: These procedures are applicable to most GTAW operations; however, always consult the manufacturer's maintenance manual for specific control adjustments.)

1. Set current range selector depending on metal thickness to low (2-60 amps), medium (10-250 amps), or high (20-300 amps)

2. Set fine adjustment current control to maximum setting if foot control is used

(NOTE: If machine is used without foot control, a specific current adjustment will be necessary as all current control will be manual at the machine.)

3. Set polarity switch to DCSP

4. Set weld control switch to GTAW

5. Set high frequency controls

   (NOTE: Welding machines not equipped with high frequency will not have these controls. If these controls are not on the machine, check the manufacturer's maintenance manual. Also, if the machine does not have high frequency, it will be necessary to have a copper starting block to avoid contamination of tungsten when striking arc.)

   a. Set high frequency spark switch to START ONLY

   b. Set high frequency spark intensity rheostate to medium setting

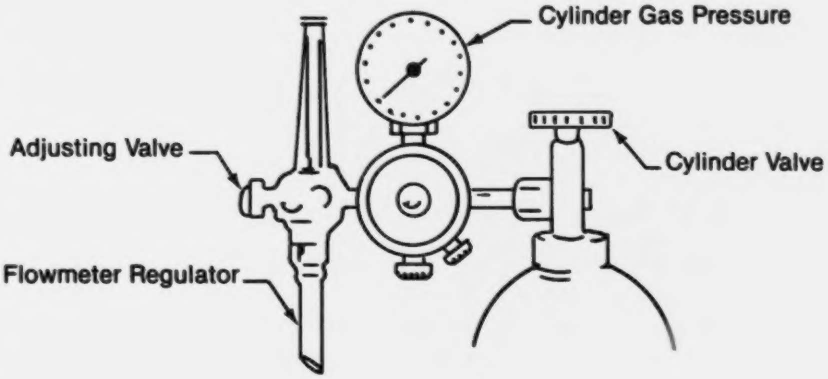
6. Switch power to ON

7. Standing to one side of cylinder, slowly open cylinder valve until fully open

8. Adjust shielding gas flow rate to 10 cfh (Figure 10)

   (NOTE: This is measured at the top of the ball.)

FIGURE 10



9. Adjust gas afterflow (post-purge) timer to 15 seconds

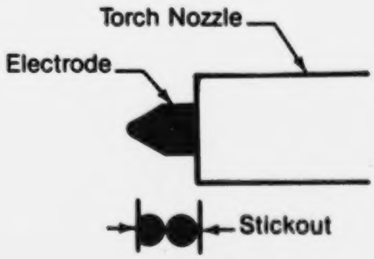
10. Set soft-start switch to OFF

11. Set foot control switch to REMOTE (if equipped)

B. Adjust electrode stickout so that electrode sticks out a length of 1 ½ times electrode diameter from torch nozzle (Figure 11)

(NOTE: Stickout distance may be increased when welding in hard-to-reach joints. Gas flow rates should be increased accordingly. Prepared tungsten should be ground to a dull point with grinding done lengthwise with the tungsten. See Figure 11.)

FIGURE 11



1 ½ to 2 Times Electrode Diameter

C. Connect ground clamp to base metal

D. Select correct filler rod type and size for mild and stainless steel from Table 5 and Table 6 at end of project guide

E. Shut down welding machine

1. Place torch where it will not arc or fall on floor

   (NOTE: GTAW torches are delicate and expensive, and they should be handled with care.)

2. Close gas cylinder valve

3. Depress foot control (if equipped) to bleed gas line

4. Close gas flow adjusting valve

   (NOTE: The ball will rest at the bottom of the gauge when the adjusting valve is closed.)

5. Turn power switch to OFF

F. Clean work area and return tools and equipment to proper storage area, or prepare for next project as directed by instructor

TABLE 5: Gas tungsten arc (TIG) welding of carbon and low alloy steel

| Material Thickness | | Type of Weld (1) | Tungsten Electrode Dia. (2) | Filler Rod Dia. | Nozzle Size I.D. | Shielding Gas C.F.H. (3) | Welding Current (Amps) DCSP (4) | Number of Passes | Travel Speed (I.P.M.) |
|---|---|---|---|---|---|---|---|---|---|
| 20 ga. | .032" | Sq. groove & fillet | 1/16 | 1/16 | 1/4 | 10 | 75-100 | 1 | 13 |
| 18 ga. | .040" | Sq. groove & fillet | 1/16 | 1/16 | 1/4 | 10 | 90-120 | 1 | 15 |
| 16 ga. | .063" | Sq. groove & fillet | 1/16 | 1/16 | 1/4 | 10 | 95-135 | 1 | 15 |
| 3/32 | .094" | Sq. groove & fillet | 3/32 | 3/32 | 5/16 | 10 | 135-175 | 1 | 14 |
| 1/8 | .125" | Sq. groove & fillet | 3/32 | 1/8 | 5/16 | 12 | 145-205 | 1 | 11 |

(1) Data is for all welding positions.

(2) For tungsten electrode, 1st choice—2% thoriated; 2nd choice—1% thoriated.

(3) Shielding gas is argon: The 75% helium, 25% argon mixture is sometimes used for heavier thicknesses.

(4) Increase amperage when backup is used.

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TABLE 6: Gas tungsten arc (TIG) welding of stainless steel

| Material Thickness | Type of Weld (1) | Tungsten Electrode Dia. (2) | Filler Rod Dia. | Nozzle Size I.D. | Shielding Gas C.F.H. (3) | Welding Current (4) (Amps)DCSP | Number of Passes | Travel (5) Speed (I.P.M.) |
|---|---|---|---|---|---|---|---|---|
| 24 ga. | Square groove | .040 | 1/16 | 1/4 | 10 | 20-50 | 1 | 26 |
| 18 ga. | " | 1/16 | 1/16 | 1/4 | 10 | 50-80 | 1 | 22 |
| 1/16 | " | 1/16 | 1/16 | 1/4 | 12 | 65-105 | 1 | 12 |
| 1/16 | Fillet | 1/16 | 1/16 | 1/4 | 12 | 75-125 | 1 | 10 |
| 3/32 | Square groove | 1/16 | 3/32 | 1/4 | 12 | 85-125 | 1 | 12 |
| 3/32 | Fillet | 1/16 | 3/32 | 1/4 | 12 | 95-135 | 1 | 10 |
| 1/8 | Square groove | 1/16 | 3/32 | 5/16 | 12 | 100-135 | 1 | 12 |
| 1/8 | Fillet | 1/16 | 3/32 | 5/16 | 12 | 115-145 | 1 | 10 |
| 3/16 | Square groove | 3/32 | 1/8 | 5/16 | 15 | 150-225 | 1 | 10 |
| 3/16 | Fillet | 1/8 | 1/8 | 3/8 | 15 | 175-250 | 1 | 8 |
| 1/4 | V-groove | 1/8 | 3/16 | 3/8 | 18 | 225-300 | 2 | 10 |
| 1/4 | Fillet | 1/8 | 3/16 | 3/8 | 18 | 225-300 | 2 | 10 |
| 3/8 | V-groove | 3/16 | 3/16 | 1/2 | 25 | 220-350 | 2-3 | 10 |
| 3/8 | Fillet | 3/16 | 3/16 | 1/2 | 25 | 250-350 | 3 | 10 |
| 1/2 | V-groove | 3/16 | 1/4 | 1/2 | 25 | 250-350 | 3 | 10 |
| 1/2 | Fillet | 3/16 | 1/4 | 1/2 | 25 | 250-350 | 3 | 10 |

(1) Data is for flat position. Reduce amperage 10% to 20% when welding is horizontal, vertical, or overhead position.

(2) For tungsten electrodes—1st choice 2% thoriated; 2nd choice 1% thoriated.

(3) Argon is used for shielding. The 75% helium 25% argon mixture is used for heavier thicknesses.

(4) Increase amperage when backup is used.

(5) Travel speed per pass of multi-pass weld.

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# A204 AIRCRAFT WELDING
# PERFORM GAS TUNGSTEN ARC WELDING
# A204-D

## PROJECT GUIDE #3 — Make Stringer Beads on 1/16-Inch Aluminum With Filler Rod in Flat Position

PURPOSE: To develop competency in the skill of making stringer beads on aluminum with filler rod in flat position using gas tungsten arc welding.

REFERENCE MANUAL: Manufacturer's manual for gas tungsten arc welding machine

EQUIPMENT AND TOOLS:

A. GTAW welding machine and required equipment

B. Safety goggles or glasses

C. Protective clothing

D. Welding helmet

E. Clean stainless steel wire brush

F. 3/32-inch collet and collet body

G. Nozzle with 5/16-inch inside diameter

SUPPLIES AND MATERIALS:

A. 3/32-inch pure tungsten electrode

B. 3/32-inch filler rod of correct composition

C. Argon

D. Two 2" × 6" pieces of aluminum, 1/16 inch thick

PROCEDURE:

(NOTE: Safety glasses or goggles should be worn in the shop at all times.)

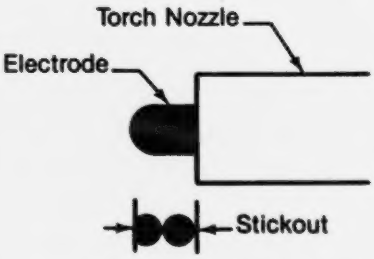
A. Clean aluminum with stainless steel wire brush to remove oxide coating

B. Check torch

   1. Check nozzle to make sure it is unburnt and has even end with no cracks or chips

2. Check tungsten to see that it has round, shiny end and is adjusted to correct stickout (Figure 12)

FIGURE 12



1 ½ to 2 Times Electrode Diameter

3. Finger tighten cap to secure tungsten

C. Attach ground clamp

D. Set welding machine

(NOTE: These procedures are applicable to most GTAW operations; however, always consult the manfacturer's maintenance manual for specific control adjustments.)

1. Set polarity switch to AC
2. Set weld control switch to GTAW
3. Set current range selector to medium (10-250 amps)
4. Set fine adjustment current control to maximum setting
5. Set high frequency spark switch to CONTINUOUS
6. Set high frequency spark intensity rheostat to medium setting
7. Switch power to ON

E. Set shielding gas rate to 15 to 20 cfh

F. Set gas afterflow (post-purge) timer to 15 seconds

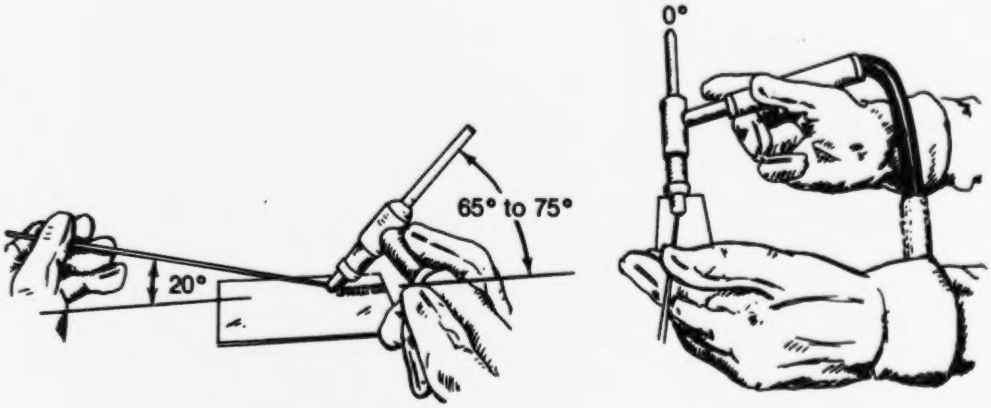
G. Position metal flat on table

H. Position torch at 60- to 75-degree angle to metal with no side angle (See Figure 13)

I. Hold electrode $^{1}/_{16}$ inch from metal (See Figure 13)

J. Hold filler rod at 20-degree angle to metal with no side angle (Figure 13)

FIGURE 13



Welder's View

End View

K. Depress foot control at least halfway and establish arc and immediate puddle

(NOTE: Do no contact metal or filler rod with tungsten.)

L. Add filler rod in leading edge of puddle, being careful to keep rod under shielding gas at all times, and complete bead

(NOTE: Consistent travel speed and addition of filler rod is the key to producing uniform beads of correct height and width.)

M. Switch or cool metal, being careful to remove all moisture before welding

N. Make additional beads, switching or cooling metal after each pass

O. Shut down equipment

P. Have instructor evaluate your work

Q. Clean work area and return tools and equipment to proper storage area, or prepare for next project as directed by instructor

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# A204 AIRCRAFT WELDING
# PERFORM GAS TUNGSTEN ARC WELDING
# A204-D

## PROJECT GUIDE #4 — Construct a Square-Groove Butt Weld on 1/8-inch Aluminum in Flat Position

PURPOSE: To develop competency in the skill of constructing a square-groove butt weld on aluminum in flat position using gas tungsten arc welding.

REFERENCE MANUAL: Manufacturer's manual for gas tungsten arc welding machine

EQUIPMENT AND TOOLS:

A. GTAW welding machine and required equipment

B. Safety goggles or glasses

C. Protective clothing

D. Welding helmet

E. Clean stainless steel wire brush

F. 1/8-inch collet and collet body

G. Nozzle with 3/8-inch inside diameter

SUPPLIES AND MATERIALS:

A. 1/8-inch filler rod of correct composition

B. 1/8-inch pure tungsten electrode, green strip

C. Argon

D. Two 2" × 6" pieces of aluminum, 1/8-inch thick

PROCEDURE:

(NOTE: Safety glasses or goggles should be worn in the shop at all times.)

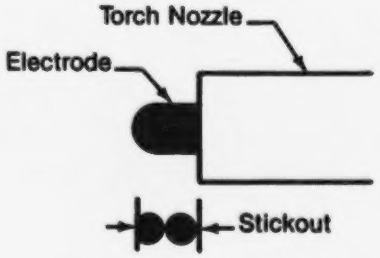
A. Clean aluminum with stainless steel wire brush to remove oxide coating

B. Check torch

1. Check nozzle to make sure it is unburnt and has even end with no cracks or chips

2. Check tungsten to see that is has round, shiny end and is adjusted for correct stickout (See Figure 14)

FIGURE 14



1 1/2 to 2 Times Electrode Diameter

3. Finger tighten cap to secure tungsten

C. Attach ground clamp

D. Set welding machine

(NOTE: These procedures are applicable to most GTAW operations; however, always consult the manufacturer's maintenance manual for specific control adjustments.)

1. Set polarity switch to AC
2. Set weld control switch to GTAW
3. Set current range selector to medium (10-250 amps)
4. Set fine adjustment current control to maximum setting
5. Set high frequency spark switch to CONTINUOUS
6. Set high frequency spark intensity rheostat to medium setting
7. Switch power to ON

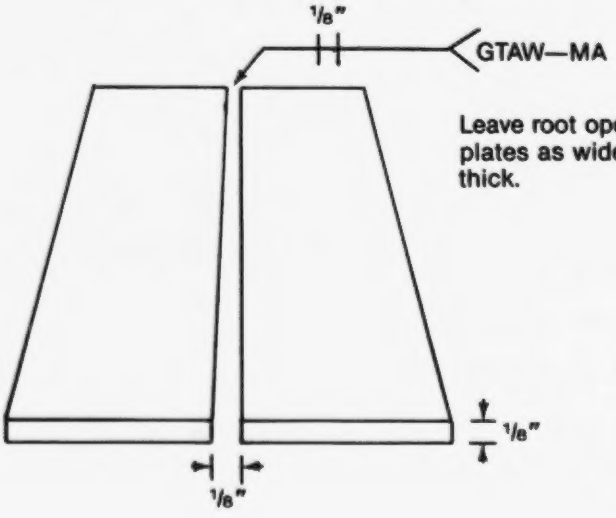
E. Set shielding gas rate to 15 to 20 cfh

F. Set gas afterflow (post-purge) timer to 15 seconds

G. Position two pieces of aluminum to form a butt joint leaving a 3/32- to 1/8-inch root opening (See Figure 15)

## PROJECT GUIDE #4

FIGURE 15

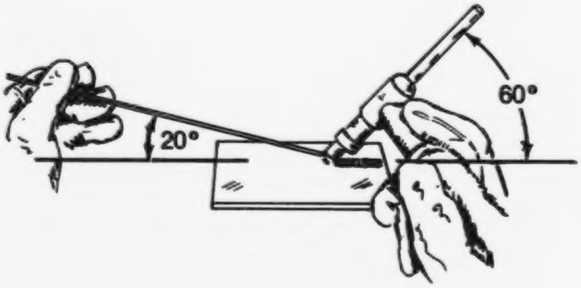


Leave root opening between plates as wide as material is thick.

H. Position torch at 60-degree angle to metal with no side angle and centered in joint, and hold electrode 1/8 inch from metal (See Figure 16)

I. Position filler rod at a 20-degree angle to metal and centered in root opening of joint (Figure 16)

FIGURE 16



J. Depress foot control, establish arc, and tack each end

K. Move to end of joint, strike arc, and establish puddle by melting rod and both plate edges

(NOTE: As weld progresses, care should be taken to maintain consistent travel speed, torch and rod angle, and correct arc length.)

## PROJECT GUIDE #4

L. Amperage should be decreased slowly with additional filler rod added to prevent crater at end of bead

M. Complete weld across joint

N. Check root of weld for penetration

O. Cool metal before welding other side

P. Repeat Steps H through N to weld other side

Q. Shut down equipment

R. Have instructor evaluate your work

S. Clean work area and return tools and equipment to proper storage area, or prepare for next project as directed by instructor

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# A204-D

## PROJECT GUIDE #5 — Construct a Lap-Joint Fillet Weld on 1/16-Inch Mild Steel with Filler Rod in Horizontal Position

PURPOSE: To develop competency in the skill of constructing a lap-joint fillet weld on mild steel with filler rod in the horizontal position using gas tungsten arc welding.

REFERENCE MANUAL: Manufacturer's manual for gas tungsten arc welding machine

EQUIPMENT AND TOOLS:

A. GTAW welding machine and required equipment

B. Safety goggles or glasses

C. Protective clothing

D. Welding helmet

E. Clean stainless steel wire brush

F. 1/16-inch collet and collet body

G. Nozzle with 1/4-inch inside diameter

SUPPLIES AND MATERIALS:

A. 1/16-inch mild steel filler rod

B. 1/16-inch, 1% or 2% thoriated tungsten

C. Argon

D. Two 2" × 6" mild steel sheets (cold roll) in clean condition, 1/16 inch thick

PROCEDURE:

(NOTE: Safety glasses or goggles should be worn in the shop at all times.)

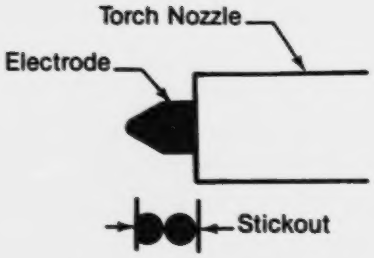
A. Clean metal with wire brush

B. Check torch

   1. Check nozzle to make sure it is unburnt and has even end with no cracks or chips

   2. Check tungsten to see that it is ground to a dull point and is adjusted to correct stickout (See Figure 17)

FIGURE 17



1 ½ to 2 Times Electrode Diameter

3. Finger tighten cap to secure tungsten

   (NOTE: It may be helpful to extend electrode 1/16 inch to 1/8 inch further to aid welder's view of puddle and increase penetration.)

C. Attach ground clamp to workpiece

D. Set welding machine

   (NOTE: These procedures are applicable to most GTAW operations; however, always consult the manufacturer's maintenance manual for specific control adjustments.)

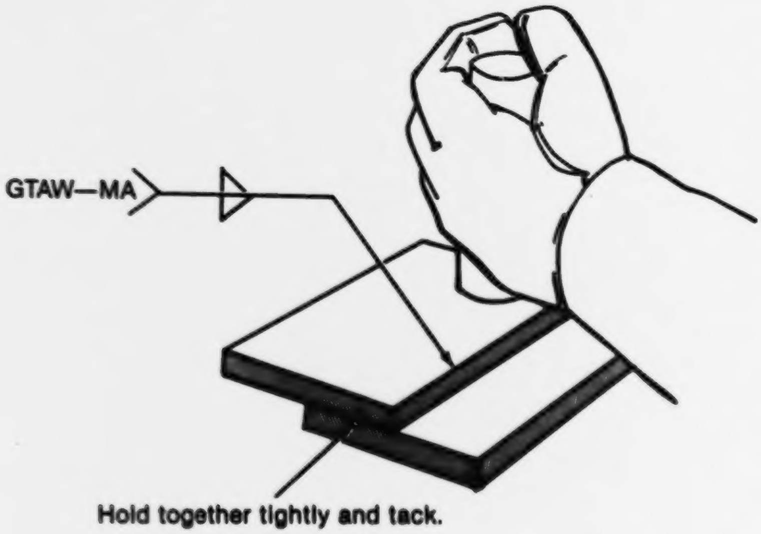
   1. Set polarity switch to DCSP
   2. Set weld control switch to GTAW
   3. Set current range selector to medium (10 to 250 amps)
   4. Set fine adjustment current control to maximum setting
   5. Set high frequency spark switch to START ONLY
   6. Set high frequency spark intensity rheostat to medium setting
   7. Switch power to ON

E. Set shielding gas rate to 10 cfh

F. Set gas afterflow (post-purge) timer to 15 seconds

G. Position mild steel sheets to form a lap joint, and tack at each end (See Figure 18)

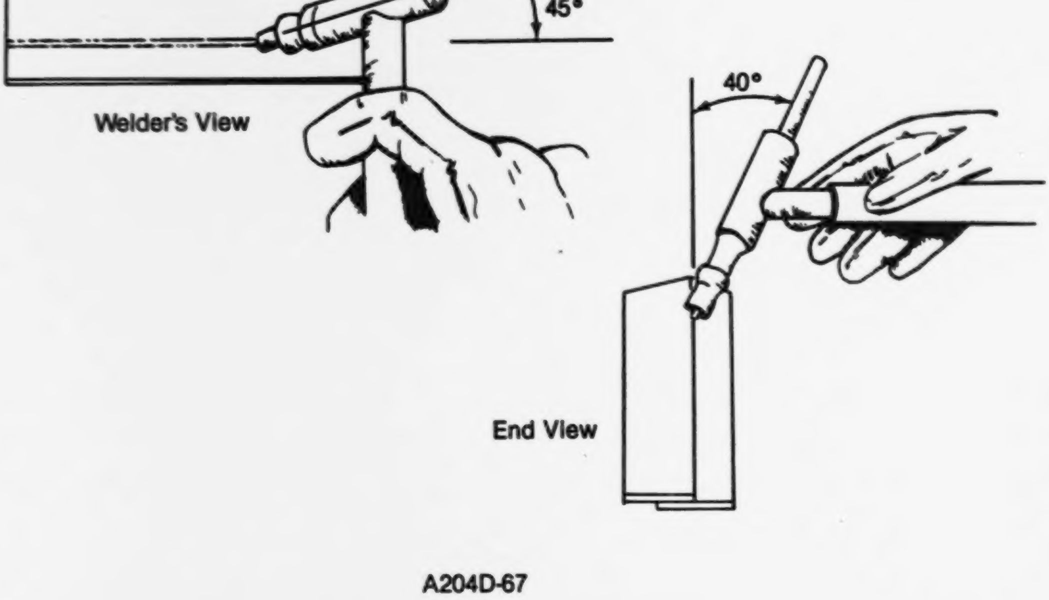
FIGURE 18


GTAW—MA
Hold together tightly and tack.

H. Place in horizontal position

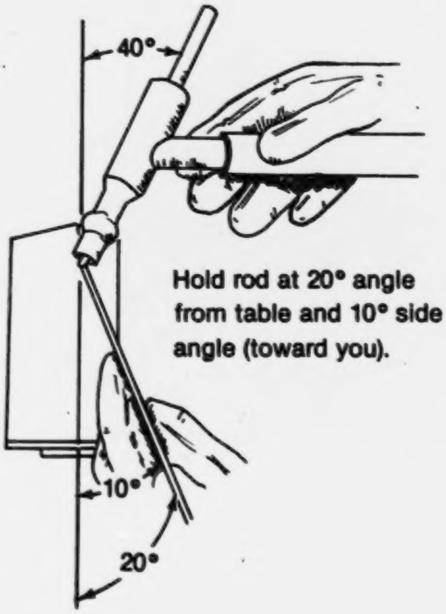
I. Position torch at a 45-degree angle from table with a 40-degree side angle toward you, holding electrode $^{1}/_{16}$ inch from metal (Figure 19)

FIGURE 19


45°
Welder's View
40°
End View

J. Hold filler rod at a 20-degree angle from table with a 10-degree side angle toward you (Figure 20)

FIGURE 20

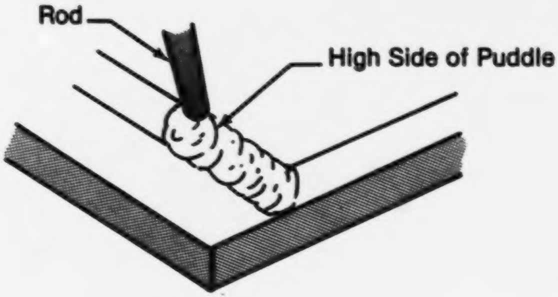


Hold rod at 20° angle from table and 10° side angle (toward you).

K. Start arc slightly in from edge, then move torch to end of joint and form puddle

L. Dip filler rod in and out at high side of puddle to prevent undercutting (Figure 21)

FIGURE 21

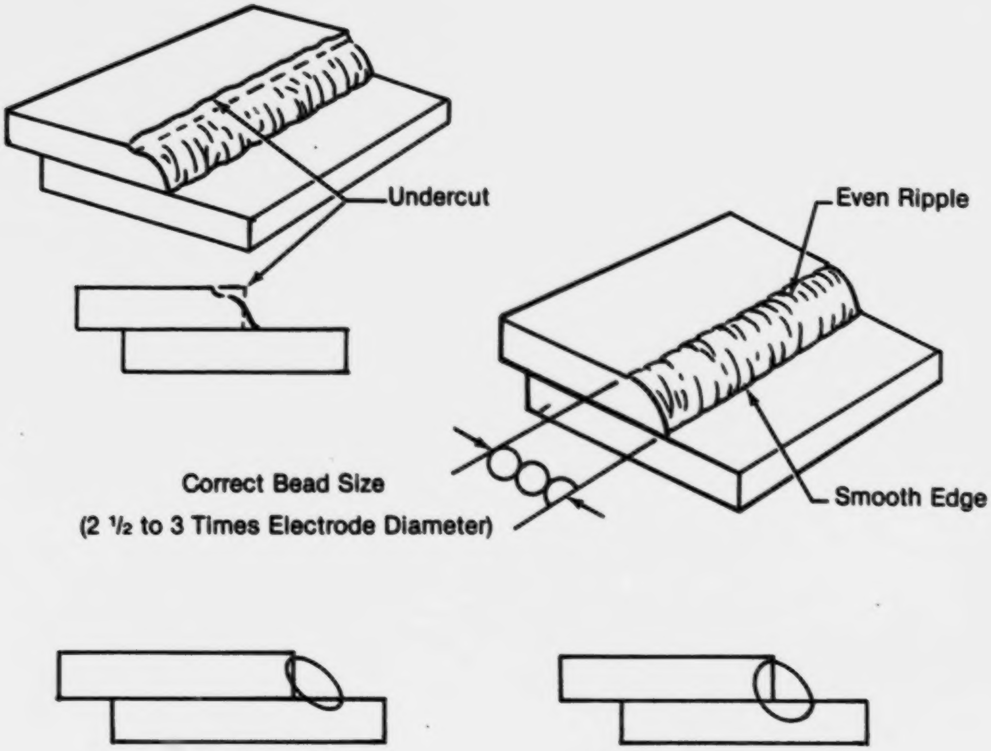


M. Complete weld across joint

N. Inspect weld for undercutting and correct bead size with even ripples and for complete penetration (Figure 22)

(NOTE: The correct size of bead face is equal to 2 ½ to 3 times the diameter of the electrode. See Figure 22.)

FIGURE 22


Undercut
Even Ripple
Correct Bead Size
(2 ½ to 3 Times Electrode Diameter)
Smooth Edge

Incomplete Penetration

Complete Penetration

O. Shut down equipment

P. Have instructor evaluate your work

Q. Clean work area and return tools and equipment to proper storage area, or prepare for next project as directed by instructor

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A204-D

## PROJECT GUIDE #6 — Repair Damage in Mild Steel Tubing Using a Welded Patch

PURPOSE: To allow you to develop skill in repairing tubing using a welded patch. You will continue to gain skill in utilizing TIG welding equipment.

REFERENCE MANUALS:

A. EA-ITP-AB

B. AC 43.13-1A&2A

C. AC 65-15A

EQUIPMENT AND TOOLS:

A. GTAW welding machine and required equipment

B. Safety goggles or glasses

C. Protective clothing

D. Welding helmet

E. Clean stainless steel wire brush

F. 1/16-inch collet and collet body

G. Copper starting block (machines without high frequency)

H. Band saw with metal blade

SUPPLIES AND MATERIALS:

A. 1/16-inch mild steel filler rod

B. One piece 4130 tubing, 12"

C. Argon

D. 1% or 2% thoriated tungsten

E. 4130 metal plate for patch (same thickness as tubing wall)

PROCEDURE:

A. Set up welding machine and equipment

(NOTE: Refer to Project Guide #5 if necessary.)

## PROJECT GUIDE #6

B. Fabricate patch according to instructions in AC 43.13-1A&2A

(NOTE: This is to be a patch repair between clusters. The simulated damage is in accordance with paragraph 73 on page 35 of AC 43.13-1A&2A.)

C. Weld patch to tubing

D. Have instructor evaluate patch

E. Shut down equipment

F. Clean work area, and return tools and equipment to proper storage area

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## A204-D

### THEORY TEST

1. Match terms related to gas tungsten arc welding to their correct definitions. Write the correct numbers in the blanks.

______a. Device used by the welder to control welding current during the welding process

______b. Thin film that forms on the surface of aluminum due to a reaction between the metal and oxygen in the air

______c. Chucking device used to hold the tungsten in the torch

______d. Science and technology of metals

______e. Arc welding process wherein coalescence is produced by heating with an arc between a nonconsumable tungsten electrode and the base metal utilizing an inert gas, argon or helium, that shields the weld zone from contamination by oxygen and nitrogen in the air

______f. Calibrated metering device used to regulate the flow of gases to the torch; measures gas flow in cubic feet per hour

______g. Holding device for the collet

______h. Attachment that fits on the end of the GTAW torch to direct the flow of shielding gas to the tungsten and weld zone

1. Gas tungsten arc welding
2. Gas cup
3. Collet body
4. Aluminum oxide
5. Flowmeter
6. Foot control
7. Collet
8. Metallurgy

_____i. Gas which will not combine with other gases

_____j. Characteristic of a metal to conduct heat throughout its thickness, width, and length

_____k. Gas pockets or voids in metal

_____l. High-voltage, low-power source introduced into the AC weld current to start the arc and aid in oxide removal when welding aluminum

_____m. Practically nonconsumable welding electrode used to create an intense arc between the tip of the electrode and the work

9. Porosity
10. Tungsten electrode
11. Inert shielding gas
12. Thermal conductivity
13. High frequency current

2. Name applications of the gas tungsten arc welding process.

a. ______________________________________________________________

______________________________________________________________

b. ______________________________________________________________

______________________________________________________________

c. ______________________________________________________________

______________________________________________________________

3. Select from the following list advantages of gas tungsten arc welding. Write an "X" in the blanks before the correct answers.

_____a. Slag and spatter easily removed

_____b. Welder has very close control of welding current

_____c. Arc and weld puddle clearly visible to welder

_____d. Welding speeds are much faster than the gas metal arc welding process

_____e. Minimum of distortion and stress with heat concentrated in small area

_____f. No flux used and no post cleaning required

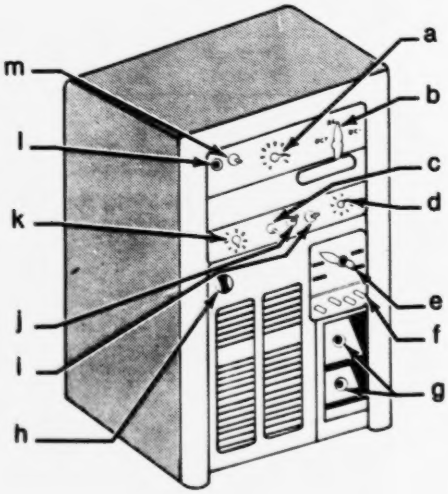
_____g. Makes excellent root pass on carbon and stainless steel pipe

_____h. Used exclusively on heavy plates where rapid production is necessary

_____i. Lends itself to assembly line use in the auto industry

## THEORY TEST

4. Label the major controls and connections of the gas tungsten arc welding machine illustrated below. Write the correct names in the blanks.



a. ______________________________

b. ______________________________

c. ______________________________

d. ______________________________

e. ______________________________

f. ______________________________

g. ______________________________

h. ______________________________

i. ______________________________

j. ______________________________

k. ______________________________

l. ______________________________

m. ______________________________

## THEORY TEST

5. State the two types of welding current used most in gas tungsten arc welding and their usages.

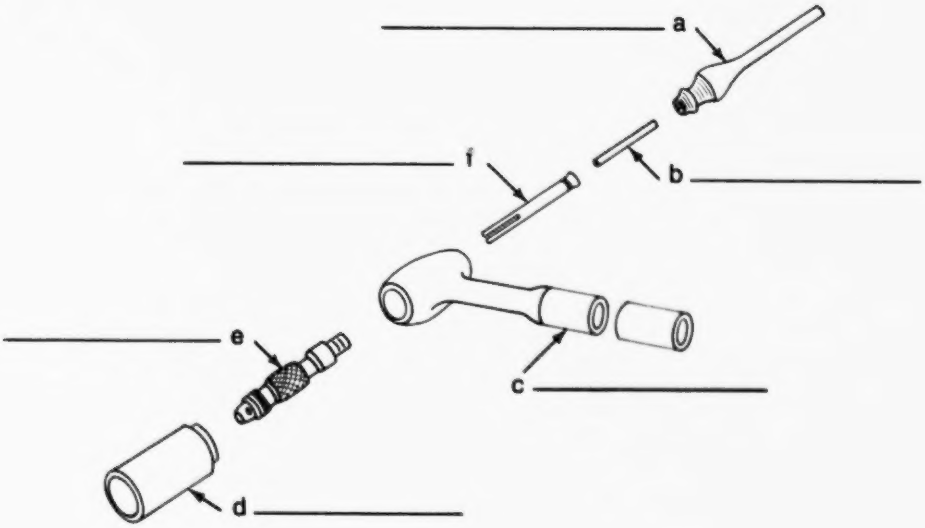
   a. 1) Type - ____________________

      2) Usage - ____________________

   b. 1) Type - ____________________

      2) Usage - ____________________

6. Label the major parts of the gas tungsten arc welding torch illustrated below. Write the correct names in the blanks.



7. Name the most commonly used types of gas cups for gas tungsten arc welding.

   a. ____________________

   b. ____________________

   c. ____________________

## THEORY TEST

8. Name the color, finish, size, and application when given the type of tungsten electrode.

| **Type of electrode** | **Color** | **Finish** | **Sizes** | **Application** |
|---|---|---|---|---|
| a. Pure | | | | |
| | | | | |
| | | | | |
| b. Zirconiated | | | | |
| | | | | |
| | | | | |
| c. 1% Thoriated | | | | |
| | | | | |
| | | | | |
| d. 2% Thoriated | | | | |
| | | | | |
| | | | | |

9. Interpret uses of aluminum and stainless steel filler metals by using Table A and Table B at the end of this test to determine the correct filler metals to use with the following base metals. Write the correct answers in the blanks.

**Aluminum**

a. Base metal 3003—____________________

b. Base metal 5052—____________________

c. Base metal 6061—____________________

d. Base metal 5005—____________________

**Stainless**

a. Base metal 347 where maximum corrosion resistance is required—__________

b. Base metal 308—____________________

c. Base metal 304 clad—____________________

d. Base metal 316—____________________

## THEORY TEST

10. State facts related to the major metallurgical factors to be considered when welding by answering the following questions.

    a. Why does aluminum require higher welding currents than other metals?

    ______________________________________________

    ______________________________________________

    b. To what heat color does aluminum change as it approaches the melting point?

    ______________________________________________

    ______________________________________________

    c. What forms on the surface of aluminum when it is exposed to oxygen in the air?

    ______________________________________________

    ______________________________________________

    d. Since some aluminum alloys melt at 900°F, what can be done to avoid distortion, collapse, and warping?

    ______________________________________________

    ______________________________________________

    e. What is the cause of weld metal warpage when welding stainless steel?

    ______________________________________________

    ______________________________________________

    f. How much slower does stainless steel dissipate heat when compared to mild steel?

    ______________________________________________

    ______________________________________________

    g. What is the difference between the melting temperatures of oxides which form on the surfaces of magnesium and aluminum in the welding process?

    ______________________________________________

    ______________________________________________

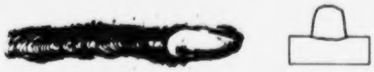
    h. What type of electrical current and shielding gas would be used when TIG welding titanium?

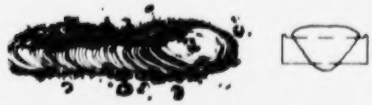
    1) Electrical current—________________________________

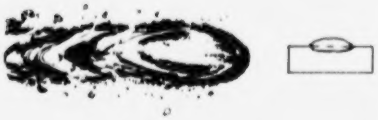
    2) Shielding gas—__________________________________

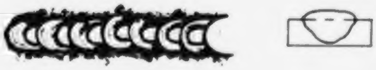
# THEORY TEST

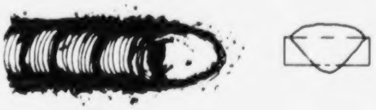
11. Match illustrations of poor welds to their causes. Write the correct numbers in the blanks.

1


2


3


4


5


______a. Welding speed to fast

______b. Welding current too high

______c. Welding speed too slow

______d. Arc too long (voltage too high)

______e. Welding current too low

12. Name characteristics of a good weld.

a. ______________________________

b. ______________________________

c. ______________________________

d. ______________________________

e. ______________________________

13. List the operational characteristics of argon and helium shielding gases used in the GTAW process.

**Argon**

a. ______________________________

b. ______________________________

c. ______________________________

d. ______________________________

**Helium**

a. ______________________________

b. ______________________________

c. ______________________________

d. ______________________________

14. The data on welded repairs which is outlined in AC 43.13-1A&2A is considered generally approved data. Select statements related to welding repair methods. Circle the numbers before the correct answers.

    a. The end of a welded sleeve repair should have a scarf angle of how many degrees?

        1) 45 degrees
        2) 60 degrees
        3) 30 degrees
        4) Any of the above

    b. What method of repair is recommended for a steel tube longeron dented at a cluster?

        1) Welded split sleeve
        2) Welded outer sleeve
        3) Welded patch plate
        4) Welded inner sleeve

(NOTE: Test questions 15-20 are project guides. They are an important part of this test. If they have not been completed, check with your instructor.)

15. Set up and shut down power supply for welding aluminum.
16. Set up and shut down power supply for welding mild and stainless steel.
17. Make stringer beads on $^{1}/_{16}$-inch aluminum with filler rod in flat position.
18. Construct a square-groove butt weld on $^{1}/_{8}$-inch aluminum in flat position.
19. Construct a lap-joint fillet weld on $^{1}/_{16}$-inch mild steel with filler rod in horizontal position.
20. Repair damage in mild steel tubing using a welded patch.

## TABLE A: Guide to the choice of filler metal for GTAW welding aluminum

| | | M | L | K | J | I | H | G | F | E | D | C | B | A |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Base metal | Casting alloys | | 6061, 6062, 6063, 6151 | 5456 | 5454 | 5154, 5254(1) | 5086, 5356 | 5083 | 5052, 5652(1) | 5005, 5050 | 3004, CLAD 3004 | 1100, 3003, CLAD 3003 | 1060 |
| | | 43, 355, 356 | 214,A214 B214,F214 | | | | | | | | | | | |
| A | 1060 | ER4043 | ER4043 | ER4043 | ER5356 (3),(5) | ER4043 | ER4043 | ER5356 (3),(5) | ER5356 (3),(5) | ER4043 | ER1100 (3) | ER4043 | ER1100 (3) | ER1260 |
| B | 1100,3003 CLAD 3003 | ER4043 | ER4043 (5) | ER4043 (5) | ER5356 (3),(5) | ER4043 (5) | ER4043 (5) | ER5356 (3),(5) | ER5356 (3),(5) | ER4043 (5) | ER4043 (5) | ER4043 (5) | ER1100 (3) | |
| C | 3004, CLAD 3004 | ER4043 | ER4043 (5) | ER4043 (2) | ER5356 (5) | ER5356 (3),(5) | ER5356 (5) | ER5356 (5) | ER5356 (5) | ER5356 (3),(5) | ER4043 (5) | ER4043 (4),(5) | | |
| D | 5005, 5050 | ER4043 | ER4043 (5) | ER4043 (2) | ER5356 (5) | ER4043 (5) | ER5356 (3),(5) | ER5356 (5) | ER5356 (5) | ER4043 (5) | ER4043 (4),(5) | | | |
| E | 5052, 5652(1) | ER4043 (5) | ER4043 (2) | ER4043 (2) | ER5356 (5) | ER5356 (2),(3) | ER5356 (2) | ER5356 (5) | ER5356 (5) | ER5652 (2),(3) | | | | |
| F | 5083 | ER5356 (3),(5) | ER5356 (5) | ER5356 (5) | ER5183 (5),(6) | ER5356 (5) | ER5356 (5) | ER5356 (5) | ER5183 (5),(6) | | | | | |
| G | 5086, 5356 | ER5356 (3),(5) | ER5356 (5) | ER5356 (5) | ER5356 (5) | ER5356 (5) | ER5356 (5) | ER5356 (5) | | | | | | |
| H | 5154 5254(1) | ER5356 (3),(5) | ER5356 (2) | ER5356 (2),(3) | ER5356 (5) | ER5356 (2) | ER5254 (2) | | | | | | | |
| I | 5454 | ER5356 (3),(5) | ER5356 (2) | ER5356 (2),(3) | ER5356 (5) | ER5554 (5) | | | | | | | | |
| J | 5456 | ER5356 (3),(5) | ER5356 (5) | ER5356 (5) | ER5556 (5),(6) | | | | | | | | | |
| K | 6061,6062 6063,6151 | ER4043 (5) | ER5356 (2),(3) | ER5356 (2),(3) | | | | | | | | | | |
| L | 214,A214 B214,F214 | ER4043 (5) | ER5356 (2) | | | | | | | | | | | |
| M | 43, 355, 356 | ER4043 (4) | | | | | | | | | | | | |

(1) Base metal alloys 5652 and 5254 are used for hydrogen peroxide service. ER5254 filler metal is used for welding both alloys for low temperature service (150° F and below). ER5652 filler metal is used for welding 5652 for high temperature service (150° F and above).

(2) ER5154, ER5254, ER5183, ER5356, ER5554, and ER5556 may be used. In some cases, they provide: 1—improved color match after anodizing treatment, 2—highest weld ductility, and 3—higher weld strength. ER5554 is suitable for elevated temperature service.

(3) ER4043 may be used for some applications.

(4) Filler metal with the same analysis as the base metal is sometimes used.

(5) ER5356, ER5183, or ER5556 may be used.

(6) ER5356 is the third choice.

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# THEORY TEST

TABLE B: Stainless steel filler metal guide for GTAW and GMAW welding

| AISI Type | Typical Wire Composition (1) | | | | | | Applications |
|---|---|---|---|---|---|---|---|
| | C | Mn | Si | Cr | Ni | Others | |
| 308L (2) | .025 | 1.8 | .40 | 20.6 | 9.7 | - - - | For welding types 304, 308, 321 & 347 |
| 308L Hi Sil (2) | .025 | 1.8 | .85 | 20.6 | 9.7 | - - - | For welding types 301, 304, particularly piping |
| 309L (2) | .025 | 1.8 | .40 | 24.0 | 13.5 | - - - | For welding 309 and straight chromium grades when heat treatment is not possible |
| 310 | .12 | 1.8 | .45 | 26.0 | 21.0 | - - - | For welding 310, 304 clad and stainless overlay (3) |
| 316L (2) | .025 | 1.8 | .35 | 19.5 | 13.0 | 2.3 Mo | For welding type 316L |
| 316L Hi Sil (2) | .025 | 1.8 | .85 | 19.5 | 13.0 | 2.3 Mo | For welding type 316, particularly piping |
| 317L (2) | .025 | 1.8 | .40 | 19.0 | 12.5 | 3.3 Mo | For welding type 317 |
| 347 | .06 | 1.3 | .40 | 19.5 | 9.5 | .90 Cb | For welding types 321 and 347 where maximum corrosion resistance is required |

(1) Remainder is iron.

(2) Hi Sil means "higher than normal silicon" (approximately double); L means "low carbon" (0.03 maximum carbon).

(3) Clad means that the metal is overlayed with stainless.

Permission granted by Hobart Brothers Company.

## AIRFRAME
## A204 AIRCRAFT WELDING
## PERFORM GAS TUNGSTEN ARC WELDING
## A204-D

### ANSWERS TO THEORY TEST

1. a. 6
   b. 4
   c. 7
   d. 8
   e. 1
   f. 5
   g. 3
   h. 2
   i. 11
   j. 12
   k. 9
   l. 13
   m. 10

2. a. Makes top quality welds possible on most metals and alloys used in industry
   b. Makes welds possible in all positions through wide range of metal thickness
   c. Used particularly for aluminum and its alloys (even on very thin sections)

3. b, c, e, f, g

4. a. Fine adjustment current control
   b. Polarity switch
   c. Soft-start switch
   d. High frequency spark intensity rheostat
   e. Current range selector
   f. Gas and water connections
   g. Ground and electrode terminals
   h. Power switch
   i. High frequency spark switch
   j. Weld control switch
   k. Shielding gas afterflow timer
   l. Remote control receptacle
   m. Remote control switch

5. a. 1) Alternating current (AC) with high frequency
      2) Aluminum and magnesium
   b. 1) Direct current straight polarity (DCSP)
      2) Mild and stainless steel

6. a. Cap
   b. Tungsten electrode
   c. Torch body
   d. Gas cup (nozzle)
   e. Collet body (holder)
   f. Collet

## ANSWERS TO THEORY TEST

7. a. Ceramic
   b. Pyrex glass
   c. Metal

8.

| | Color | Finish | Size | Application |
|---|---|---|---|---|
| a. | Green | Ground or chemically etched | 1/16, 3/32, 1/8, 5/32, 3/16, 1/4 | Aluminum and magnesium |
| b. | Brown | Ground or chemically etched | 1/16, 3/32, 1/8, 5/32, 3/16, 1/4, | X-ray quality for aluminum or magnesium |
| c. | Yellow | Ground or chemically etched | 1/16, 3/32, 1/8, 5/32, 3/16, 1/4 | Mild or stainless steel |
| d. | Red | Ground or chemically etched | 1/16, 3/32, 1/18, 5/32, 3/16, 1/4 | Mild or stainless steel |

9. **Aluminum**

   a. ER1100
   b. ER5652
   c. ER5356
   d. ER4043

   **Stainless**

   a. 347
   b. 308L
   c. 310
   d. 316L Hi Sil

10. a. Because of its high thermal conductivity
    b. None
    c. Aluminum oxide
    d. Support all areas subjected to extreme heat
    e. Very slow heat expansion in the weld zone
    f. 40 to 50 percent slower
    g. Magnesium oxides melt at far higher temperatures
    h. 1) Direct current straight polarity (DCSP)
       2) Argon gas

11. a. 4
    b. 2
    c. 5
    d. 3
    e. 1

## ANSWERS TO THEORY TEST

12. a. Smooth edge
    b. Correct bead size
    c. Even penetration
    d. Even ripple
    e. Clean, bright weld

13. **Argon**

    a. Easily obtainable at low cost
    b. Better shielding at lower flow rates than helium
    c. Easier arc starting than helium
    d. Better cleaning action when welding aluminum with AC current

    **Helium**

    a. Yields higher heat for comparable current than argon
    b. Arc length is more critical than argon
    c. Has higher welding speeds than argon
    d. Produces poor arc stability and cleaning action

14. a. 3
    b. 3

15. Performance skills evaluated to the satisfaction of the instructor

16. Performance skills evaluated to the satisfaction of the instructor

17. Performance skills evaluated to the satisfaction of the instructor

18. Performance skills evaluated to the satisfaction of the instructor

19. Performance skills evaluated to the satisfaction of the instructor

20. Performance skills evaluated to the satisfaction of the instructor

# AIRFRAME

# A204 AIRCRAFT WELDING

# COURSE TEST

### AIRFRAME
### A204 AIRCRAFT WELDING
### COURSE TEST

Read the following questions and darken the circle in the column of the corresponding letter which indicates the correct answer on the answer sheet.

1. The primary reason for using flux when welding aluminum is to

    a. Prevent oxides from forming ahead of the weld.
    b. Promote better fusion of the base metal at a lower temperature.
    c. Prevent molten metal from flowing too widely.
    d. Clean the base metal ahead of the weld.

2. Magnesium aircraft structural members are usually heat treated. Which statement is true concerning the welding of heat treated magnesium?

    a. The welded section can never have the strength of the original metal.
    b. Flux should not be used as it causes corrosion to commence.
    c. Use an oxidizing flame held at a flat angle to the work.
    d. Magnesium cannot be repaired by fusion welding.

3. The oxyacetylene flame for silver soldering should be

    a. Harsh.
    b. Oxidizing.
    c. Neutral.
    d. Carburizing.

4. Why is it necessary to use flux in all silver soldering operations?

    a. To chemically clean the base metal of oxide film.
    b. To prevent overheating of the base metal.
    c. To increase the strength of the joint and save the expensive silver solder.
    d. To increase heat conductivity.

5. Engine mount members should preferably be repaired by using

    a. A larger diameter tube with fishmouth and no rosette welds.
    b. A larger diameter tube with fishmouth and rosette welds.
    c. A smaller diameter tube with fishmouth and rosette welds.
    d. A larger diameter tube with 30 degree cuts and rosette welds.

6. What method of repair is recommended for a steel tube longeron dented at a cluster?

    a. Welded split sleeve.
    b. Welded outer sleeve.
    c. Welded patch plate.
    d. Welded inner sleeve.

# COURSE TEST

7. Welding over a previously brazed or soldered joint is

   a. Not permitted.
   b. Permitted only if welding temperatures do not exceed 2000°F.
   c. Permitted only if all traces of the braze or solder material are removed by chemical treatment.
   d. Permitted only if done within a carefully controlled reducing atmosphere.

8. When a wire or cable is to be permanently attached to an electrical component by soldering

   a. The wire or cable should be thoroughly tinned prior to attachment to increase its flexibility.
   b. The joint should be mechanically secure before soldering.
   c. The joint should be able to depend upon the solder for its mechanical strength.
   d. The solder should be made to coat the wire completely and smoothly and not penetrate between the wire strands.

9. In aircraft welding, the usual practice in the selection of a welding tip is to use

   a. The type of material to be welded as the primary basis for selection.
   b. A tip with a hole size to the diameter of the welding rod used.
   c. As small a tip as possible with the tip adjusted to the maximum operating range.
   d. As large a tip as possible with the tip adjusted to the maximum operating range.

10. Why should a carburizing flame be avoided when welding steel?

    a. It removes the carbon content.
    b. It hardens the surface.
    c. It causes excessive sparking.
    d. A cold weld will result.

11. Which item listed below is the most important consideration when selecting a welding rod?

    a. Type of torch.
    b. Type of metal to be welded.
    c. Thickness of the metal to be welded.
    d. Regulator pressure.

12. When welding a tank fabricated from 0.071 sheet aluminum, a welding tip slightly larger than that used for welding steel of the same thickness should be used to obtain sufficient heat to melt the base metal. The flame used for aluminum welding should

    a. Be neutral and soft.
    b. Be slightly oxidizing.
    c. Contain an excess of acetylene and leave the tip at a relatively low speed.
    d. Contain an excess of acetylene and leave the tip at a relatively high speed.

13. Why should a new or resurfaced soldering copper tip be tinned or coated with solder?

    a. To aid in the transfer of heat from the soldering tip to the joint to be soldered.
    b. So that the solder on the tip will transfer to the joint to be soldered as soon as the proper temperature is reached.
    c. To prevent the soldering tip from overheating the joint to be soldered.
    d. To prevent excessive heat from being radiated from the tip.

14. A very thin and pointed tip on a soldering copper is undesirable because it will

    a. Burn the alloys out of the solder.
    b. Be very difficult to tin.
    c. Cool too rapidly.
    d. Punch holes in the metal being soldered.

15. When welding SAE 4130 steel, a soft neutral flame should be used because a

    a. Harsh carbonizing flame will burn the molybdenum out of the weld.
    b. Harsh neutral flame may produce cold shuts and laps.
    c. Soft oxidizing flame will not produce enough heat to melt the base metal.
    d. Soft reducing flame may cause an iron oxide slag to form on the weld.

16. A gas weld which is successfully completed should have which of the following characteristics?

    a. The finish weld should have a rough seam and be nonuniform in thickness.
    b. The weld metal should be tapered smoothly into the base metal.
    c. Oxide should be formed on the base metal close to the weld.
    d. The base metal should show signs of pits.

17. An acceptable line pressure for acetylene is

    a. 5 psi.
    b. 18 psi.
    c. 22 psi.
    d. The same as the oxygen pressure.

18. Cylinders used to transport and and store acetylene

    a. Are purged after each use.
    b. Are pressure tested to 3,000 psi.
    c. Are green in color.
    d. Contain acetone.

19. Which of the following statements concerning a welding process is true?

    a. The inert-arc welding process uses an inert gas to protect the weld zone from the atmosphere.
    b. In the metallic-arc welding process; filler material, if needed, is provided by a separate metal rod of the proper material held in the arc.
    c. In the carbon-arc welding process; filler material, if needed, is provided by the carbon rod.
    d. In the oxyacetylene welding process, the filler rod used for steel is covered with a thin coating of flux.

20. Where should the flux be applied when oxyacetylene welding aluminum?

    a. Painted only on the surface to be welded.
    b. Painted on the surface to be welded and applied to the welding rod.
    c. Applied only to the welding rod.
    d. Painted on the surface to be welded and applied to the welding rod after tack weld.

21. What purpose does flux serve in welding aluminum?

    a. Removes dirt, grease, and oil.
    b. Minimizes or prevents oxidation.
    c. Ensures proper distribution of the filler rod.
    d. Aids in the fusing of the base metal but not the filler rod.

22. Why are aluminum plates one-fourth inch or more thick usually preheated before welding?

    a. Reduces internal stresses and assures more complete penetration.
    b. Reduces welding time.
    c. Prevents corrosion and ensures proper distribution of flux.
    d. Removes oxide dirt, grease, and oil.

# COURSE TEST

23. How should a welding torch flame be adjusted to weld stainless steel?

a. Slightly carburizing.
b. Slightly oxidizing.
c. Neutral.
d. Heavy.

24. Oxides form very rapidly when alloys or metals are hot. It is important, therefore, when welding aluminum to use a

a. Solvent.
b. Float.
c. Filler.
d. Flux.

25. If gas welding, the amount of heat applied to the material being welded is controlled by

a. The amount of gas pressure used.
b. The size of the tip opening.
c. The distance the tip is held from the work.
d. The temperature of the flame.

26. Oxygen and acetylene cylinders are made of

a. Heat-treated seamless copper.
b. Seamless aluminum.
c. Steel.
d. Bronze.

27. The maximum working pressure of acetylene when welding should never exceed

a. 15 psi.
b. 29 psi.
c. 25 psi.
d. 6 psi.

28. When inspecting a butt welded joint by visual means,

a. The penetration should be 25 percent to 50 percent of the thickness of the base metal.
b. The width of the bead should be twice the thickness of the base metal.
c. The penetration should be 100 percent of the thickness of the base metal.
d. Look for evidence of excessive heat in the form of a very high bead.

## COURSE TEST

29. Annealing of aluminum

    a. Increases the tensile strength.
    b. Makes the material brittle.
    c. Removes stresses caused by forming.
    d. Makes the material hard.

NAME____________________

DATE____________________

# AIRFRAME
# A204 AIRCRAFT WELDING
# ANSWERS TO COURSE TEST

| | a | b | c | d | | a | b | c | d |
|---|---|---|---|---|---|---|---|---|---|
| 1. | ● | ○ | ○ | ○ | 16. | ○ | ● | ○ | ○ |
| 2. | ● | ○ | ○ | ○ | 17. | ● | ○ | ○ | ○ |
| 3. | ○ | ○ | ● | ○ | 18. | ○ | ○ | ○ | ● |
| 4. | ● | ○ | ○ | ○ | 19. | ● | ○ | ○ | ○ |
| 5. | ○ | ● | ○ | ○ | 20. | ○ | ● | ○ | ○ |
| 6. | ○ | ○ | ● | ○ | 21. | ○ | ● | ○ | ○ |
| 7. | ● | ○ | ○ | ○ | 22. | ● | ○ | ○ | ○ |
| 8. | ○ | ● | ○ | ○ | 23. | ● | ○ | ○ | ○ |
| 9. | ● | ○ | ○ | ○ | 24. | ○ | ○ | ○ | ● |
| 10. | ○ | ● | ○ | ○ | 25. | ○ | ● | ○ | ○ |
| 11. | ○ | ● | ○ | ○ | 26. | ○ | ○ | ● | ○ |
| 12. | ● | ○ | ○ | ○ | 27. | ● | ○ | ○ | ○ |
| 13. | ● | ○ | ○ | ○ | 28. | ○ | ○ | ● | ○ |
| 14. | ○ | ○ | ● | ○ | 29. | ○ | ○ | ● | ○ |
| 15. | ○ | ● | ○ | ○ | | | | | |